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Kentucky Lock and Dam, Tennessee River, Kentucky

Navigation Study

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An AVI file is linked to the electronic version of this report showing video images of the railroad bridge truss being moved from the left bank boat basin into the lower lock approach with the four flow conditions identified in the "Railroad Truss Float-in" section (Chapter 3) of this report. The AVI file can be found at: http://libweb.wes.army.mil/uhtbin/hyperion/CHL-TR-02-3.pdf.

14. ABSTRACT

A 1:100 physical navigation model was built to replicate the Kentucky Lock and Dam at approximately river mile 22.4 of the Tennessee River. The model reproduced approximately 0.1 miles immediately upstream of the dam and approximately 1.9 miles downstream of the dam. The model study was performed primarily to determine navigation conditions that would be associated with the contruction of a 1,200-ft lock and 1,200-ft guide wall landward of the existing 600-ft lock and to improve any noted navigation deficiencies. The model was also used to develop structures to decrease the size and strength of a large eddy that forms below the spillway during certain flow conditions and operation of the dam. The model was also used to evaluate any impacts on navigation that would result due to construction of proposed fishing jetties and piers. This report describes all plans evaluated in the model and the reuslts of these plans.

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I-24 bridge
Kentucky Lock and Dam
Navigation
Powerhouse
Powerhouse Island
Tennessee River
Truss float-in

ERDC/CHL TR-02-3
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Kentucky Lock and Dam, Tennessee River, Kentucky

Navigation Study

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Final report

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Contents

List of Figures

Preface

This study was conducted for the U.S. Army Engineer District, Nashville, in the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center, (ERDC), Vicksburg, MS, during the period September 1998 through April 2001.

During the course of the model study, representatives of the Nashville District, Tennessee Valley Authority (TVA), Kentucky Department of Wildlife and Fish Resources (KDWFR), U.S. Department of Fish and Wildlife, various navigation interests, and contracting firms involved in the design of the proposed structures visited ERDC at different times to observe model operations and discuss experiment results. The Nashville District was kept informed of the progress of the study through monthly progress reports, periodic e-mail and telephone conversations, briefings, and letter reports on key segments of the model testing during the course of the study.

The investigation was conducted under the general supervision of Mr. Thomas W. Richardson, Director, CHL, Mr. Thomas J. Pokrefke, Acting Assistant Director, CHL, and under the direct supervision of Dr. Sandra K. Knight, Chief, Navigation Branch. The principal investigator in charge of the model and preparation of the report was Mr. Randy A. McCollum, assisted by Mr. B. T. Crawford, both of the Navigation Branch. Mr. Danny Marshall, also of the Navigation Branch, assisted during the course of the study.

Dr. Steve Wilhelms, a research hydraulic engineer, group leader for the Environmental Hydraulics Group, CHL, assisted in evaluating the recirculation, mixing, and gas supersaturation characteristics of this project.

Mr. Charlie Ritchie of Vulcan Materials, Inc., assisted in the development of the preliminary design for Plan B-2 during the period of 29-31 March 2000.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

Conversions Factors Non-SI to SI Units of Measurement

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers
cubic feet	0.028317	cubic meters

1 Introduction

Location and Description of Prototype

The Kentucky Lock and Dam is located on the Tennessee River at river mile 22.4, which is approximately 20 miles east-southeast of Paducah, KY (Figure 1 and Photo 1). The existing project is a 600-ft[1] by 110-ft lock chamber along the right descending bank line, a wedge-shaped island on the left side of the lock, a five-turbine unit powerhouse on the left side of the island, and a 24-gate spillway. Each spillway bay is 40 ft wide and is made up of three individual leaf gates. The upper gate is 14 ft tall and the two lower gates are 18 ft each, totaling 50 ft. The upper pool elevation and flow regulation was achieved by the addition or removal of the leaf gates in sequences established by the Tennessee Valley Authority (TVA). The crest elevation of the spillway is 325 ft. The powerhouse turbine units are being upgraded and when completed will provide for maximum discharge through the powerhouse of up to 80,000 cfs with a 60-ft head differential.

Existing Conditions

The largest typical barge configuration was 15 (3 wide by 5 long); 105 ft by 975 ft with a typical push towboat of approximately 100 ft. The upper pool has almost no current, and navigation conditions are almost exclusively related to the strength and direction of wind, especially for lightly loaded or empty tows. Navigation conditions in the downstream approach for upbound tows are generally not excessively difficult for any flow conditions. Downbound tows experience increasing difficulty in getting out into the navigation channel and aligned to pass through the navigation span of the Interstate 24 bridge as discharge through the powerhouse and spillway increase. This difficulty has not been reported as excessive or dangerous, and there has been no record of accidents in which the bridge piers at the edges of the navigation span have been struck. Typically when there was a downbound tow either in the lock or approaching the lock, an upbound tow will tie off and wait on the mooring cells along the descending left bank immediately upstream of the I-24 bridge until the downbound tow has cleared. Tows rarely use the mooring cells, which are immediately downstream of the powerhouse island.

[1] A table for converting non-SI units of measurement to SI units of measurement can be found on page vii.

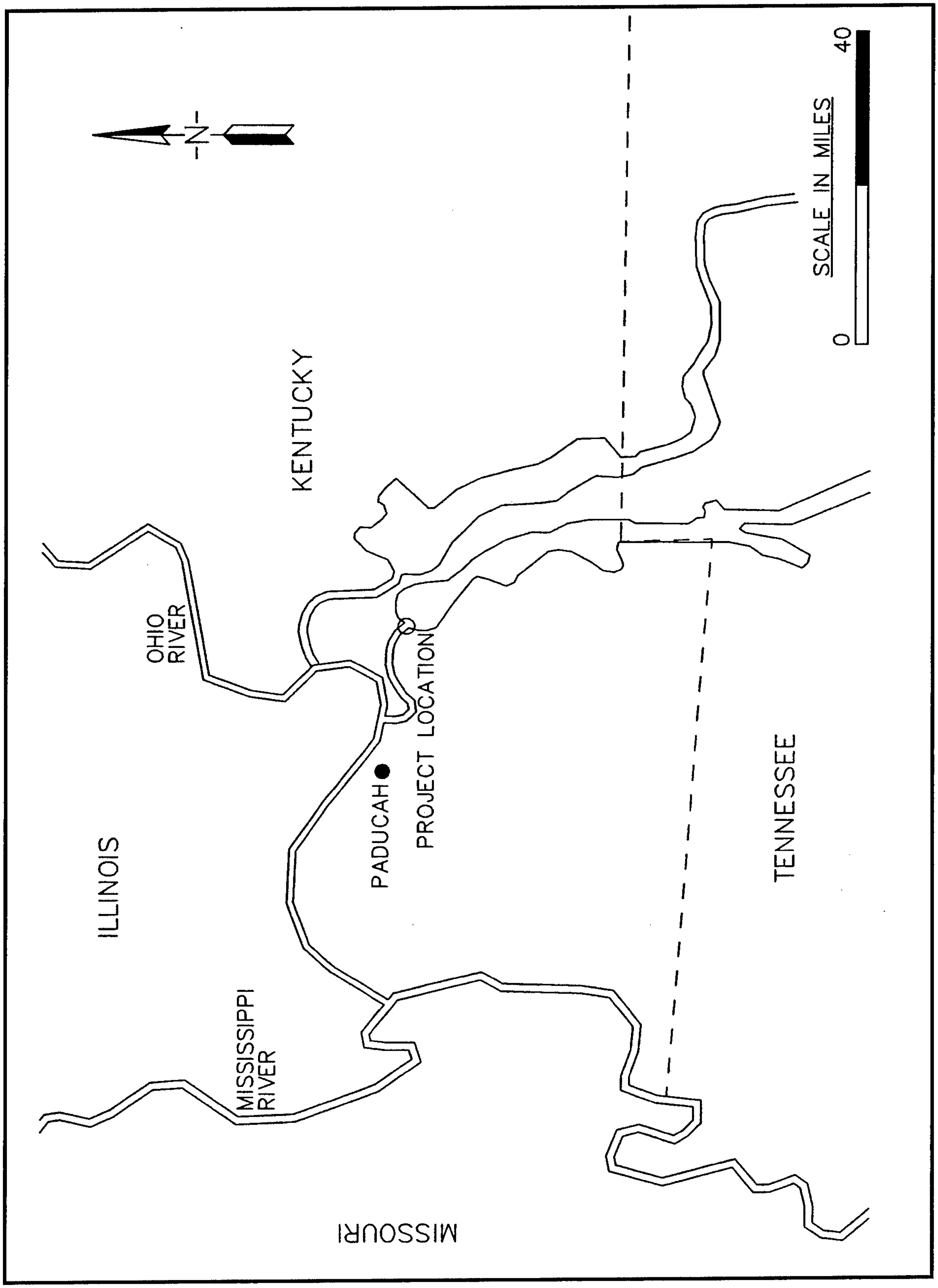


Figure 1. Vicinity map

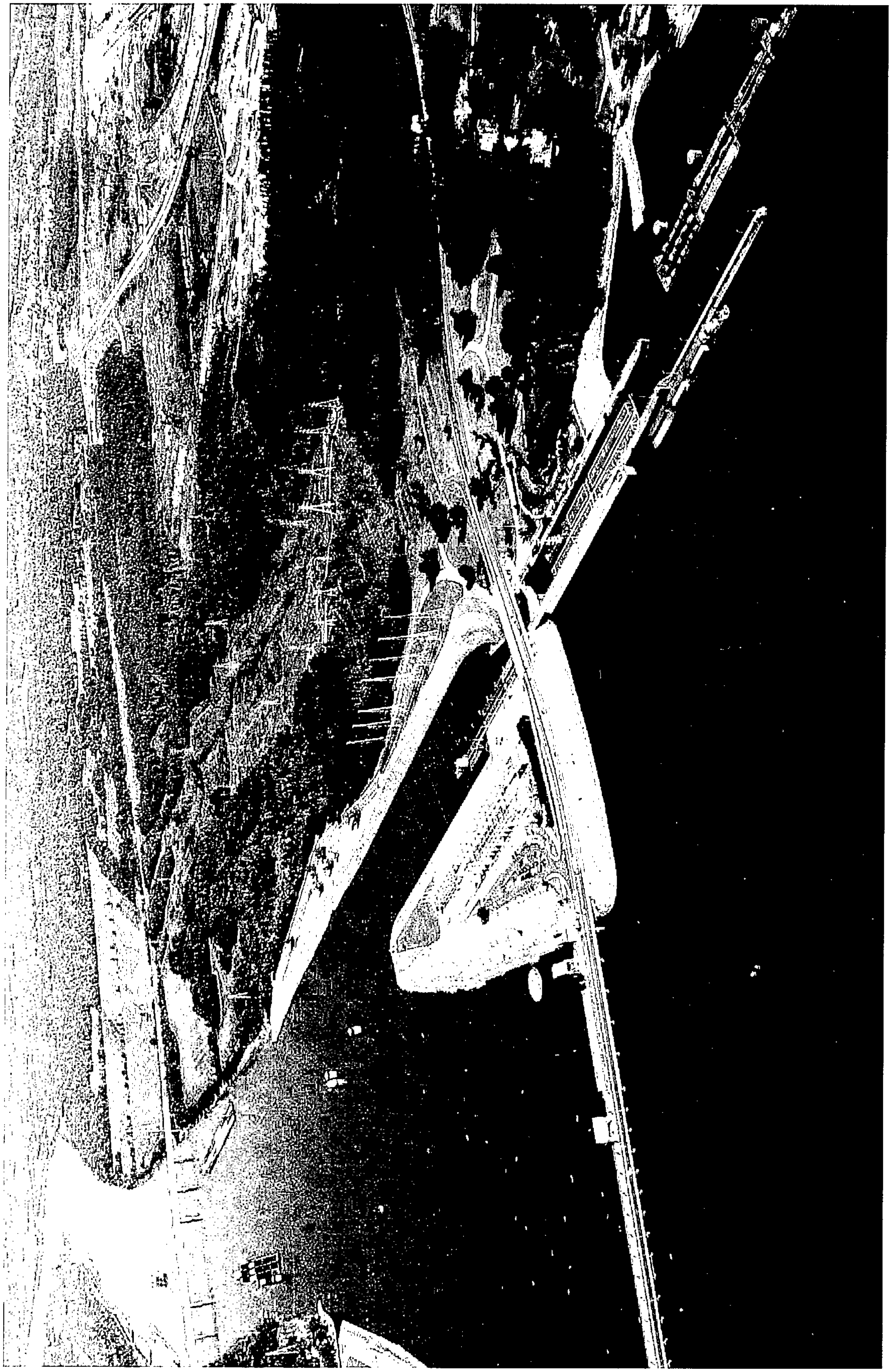


Photo 1. Kentucky Lock and Dam, Tennessee River

Most tows passing through the lock exceed the chamber length. This requires the tow to be broken apart and locked through in two sections, then reassembled to continue. This often causes delays and a backlog of traffic at this site.

Purpose of Model Study

A new 1,200-ft by 110-ft lock was proposed to be built landward of the existing lock (Figure 2). The landward wall of the existing lock and the short landside guide wall are to be incorporated into the left wall of the proposed lock and form the middle wall separating the locks. A 1,200-ft solid landside guide wall was to be added downstream of the proposed lock (Photo 2). As part of the construction, the existing state highway and railroad track that run along the left bank spillway embankment and over the spillway and powerhouse and over the existing lock would be relocated. New highway and railroad bridges are to be built to cross the downstream end of the powerhouse island and over the top of the proposed lock. Also, fishing piers are to be constructed on the right and left banks immediately upstream of the proposed highway bridge and fishing jetties are to be constructed on the left bank immediately upstream of the left bank mooring cells.

Downbound navigation from the existing lock was increasingly difficult as discharge rises from the powerhouse and spillway. The combined effects on navigation of the new lock, proposed bridges, fishing jetties, and piers are uncertain.

The present operation of the powerhouse and spillway gates creates a large counterclockwise eddy that ranges from the stilling basin, off the west side of the powerhouse island, across the channel to the left bank, then back up the left bank and across the spillway. The size and strength of this eddy varies with the flow condition. The tendency for flow to move upstream along the left bank and across the spillway presents a potential hazard to the fishers and pleasure craft in this area. Controlling the size and strength of this eddy, especially during release conditions that would permit small pleasure craft to be in this area was considered to be desirable by the Kentucky Department of Wildlife and Fish Resources (KDWFR).

At the request of the U.S. Army Engineer District, Nashville, navigation studies were proposed. A physical model study was recommended due to the complexities of the study reach. The model was proposed to include only the downstream approach to the existing and proposed locks since the wind conditions that dictate navigation conditions in the upstream approaches could not be replicated in the physical model. The objectives of the 1:100 scale undistorted model, using a radio-controlled model towboat and barges are as follows:

a. Examine navigation conditions in the downstream approach to the proposed lock and develop training works, if needed, to improve any adverse conditions noted.

b. Examine impacts of structures to be added during project on navigation.

    (1) Fishing jetties along descending left bank upstream of the I-24 bridge.

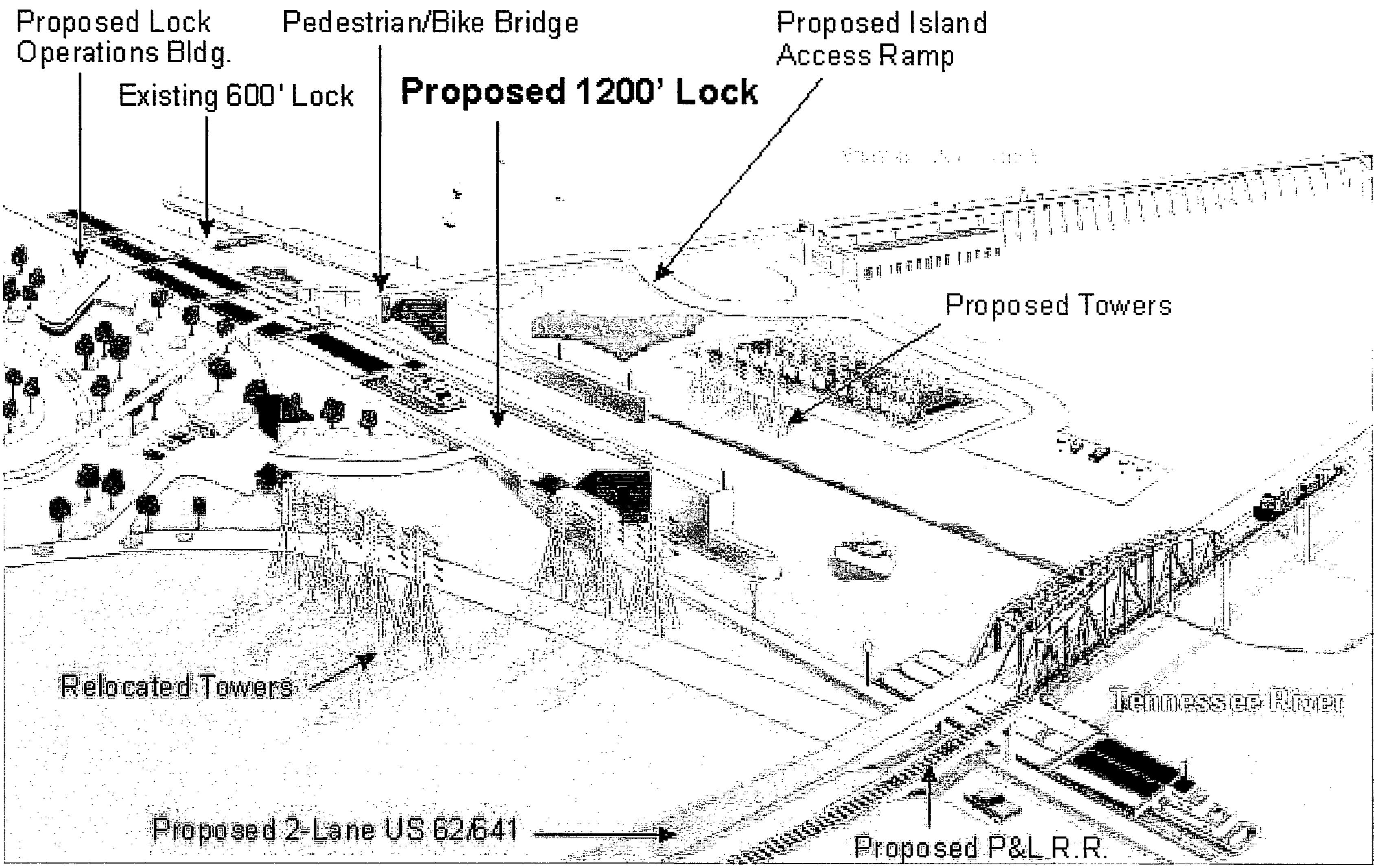


Photo 2. Proposed improvements, Kentucky Lock and Dam

(2) Fishing piers on right and left banks underneath the proposed highway bridge.

(3) Bridge piers of proposed highway and railroad bridges on the east side of powerhouse island.

c. Examine navigation conditions during the various construction phases of the project.

d. Examine alternatives to reduce the size and strength of the counter-clockwise eddy downstream of the spillway during critical release conditions to enhance safety for recreational boaters.

e. Determine local velocities near proposed bridge piers and training structures.

f. Obtain current velocities throughout the water column for existing and postproject conditions to aid in assessing environmental impacts.

2 Physical Model

Description

The model (Figure 2) reproduced about 2.0 miles of the Tennessee River starting about 0.1 miles upstream of Kentucky Lock and Dam and extending downstream of the dam about 1.9 miles. The model reproduced the west bank embankment, the 24-gate spillway, the five-turbine unit powerhouse, powerhouse island, the existing 600-ft by 110-ft lock, the existing downstream guide walls, and the I-24 bridge piers and approaches. The model limits were established to incorporate as much of the area that would be inundated at the maximum tail-water elevation (el 344.0) as possible. The model was of the fixed-bed type with overbank areas and channels molded of sand cement mortar to sheet metal templates set to the proper grade. Portions of the model where changes in bank alignment and placement of new structures could be anticipated were molded in sand and overlaid with a thin layer of sand cement mortar to facilitate modifications necessary to determine navigation conditions associated with the various plans. The spillway, lock, powerhouse, guide walls, and bridge piers were constructed of sheet metal and/or Plexiglas and set at the proper grade. The lock gates were simulated schematically with simple vertical sheet metal slide-type gates. The powerhouse had individual slide type gates for each turbine unit. The gates were designed to allow flow to pass over the top of them. The inlet and outlet ports of the powerhouse were constructed to the proper size and elevation. Individual spillway gates were made for each gate bay to replicate the leaf gates used in the prototype. Gates could be changed in each gate bay to replicate having a single 18-ft leaf or two 18-ft leafs in place, based on the flow condition to be reproduced and the specified gate openings for this flow condition as established by the Spillway Discharge Tables, dated December 1948, provided by the TVA. The entire channel and overbanks from the spillway downstream to the I-24 bridge were molded to conform to surveys taken in August 1998 and provided by the Nashville District in a MicroStation drawing file. The remaining overbank from the I-24 bridge downstream to the end of the model was molded to contours obtained from the Calvert City, KY, 1:24000 quadrangle map, dated 1993.

Scale Relations

The model was built to an undistorted linear scale of 1:100, model to prototype. This scale allows accurate reproduction of velocities, eddies, and

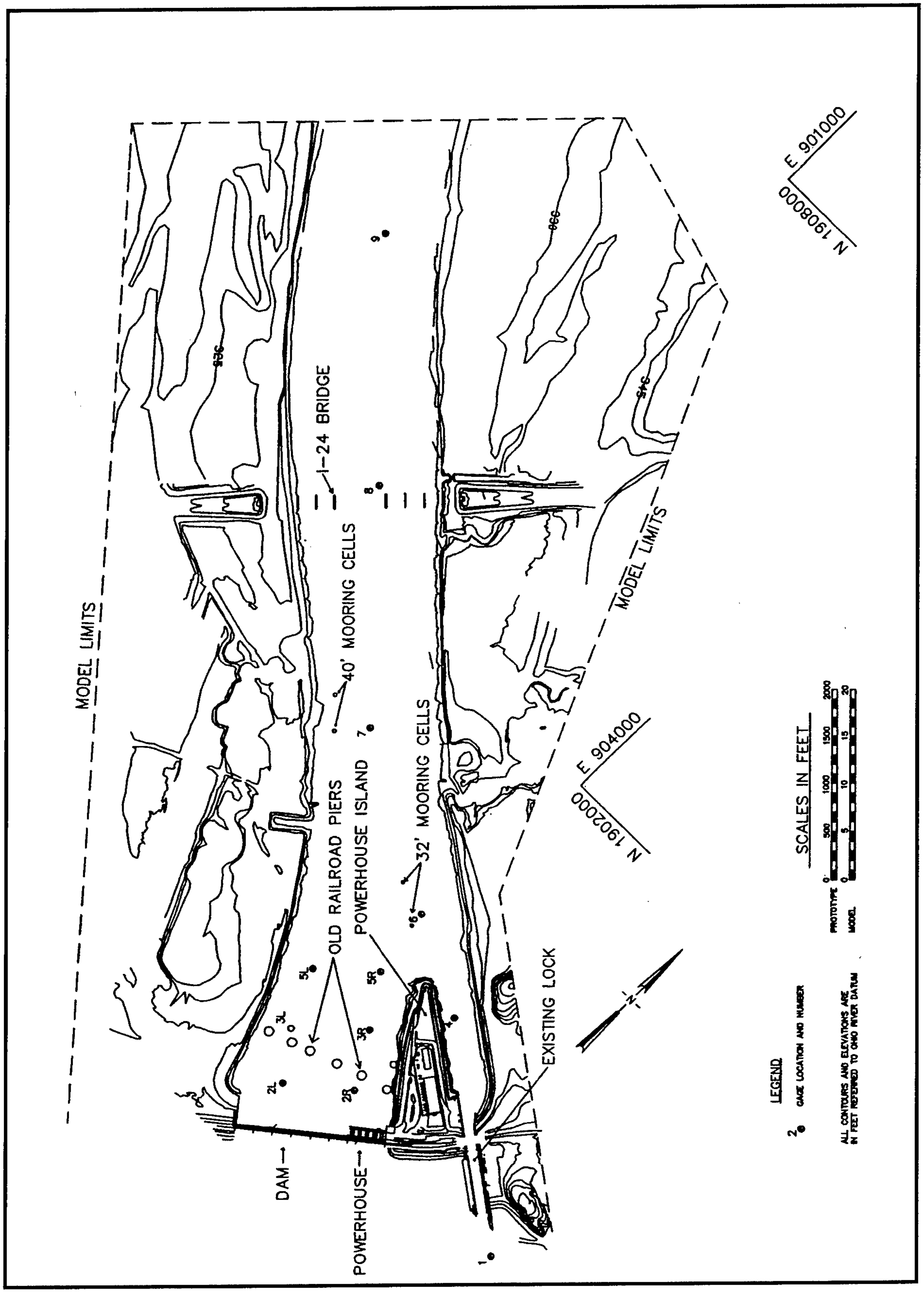


Figure 2. Model layout

crosscurrents that would affect navigation. Other scale ratios resulting form the linear scale ratio are as follows:

Characteristic	Ratio[1]	Scale Relations Model:Prototype
Length	Lr	1:100
Area	Ar = Lr2	1:10,000
Velocity	Vr = Lr1/2	1:10
Time	Tr = Lr1/2	1:10
Discharge	Qr = Lr5/2	1:100,000
Roughness (Manning's n)	Nr = Lr1/6	1:2.154
[1] Dimensions are in terms of length L..		

Measurements of discharges, water-surface elevations, and current velocities can be transferred quantitatively from model to prototype using these scale relations.

Appurtenances

Water was supplied to the model by a 10-cfs pump operating in a recirculating system. The discharge was controlled and measured by a valve and a 10-in. × 5-in. venturi meter. Water-surface elevations were measured by piezometer gages located in the model channel (Figure 2) and connected to a centrally located gage pit. A tailgate was provided at the end of the model to regulate the tailwater elevation.

Model Validation

The surface of the model was constructed of brushed cement mortar to provide a roughness (Manning's n) of about 0.0135, which corresponds to a roughness in the prototype of about 0.029. The powerhouse units were calibrated by closing off all flow through the spillway, setting the proper discharge coming into the model, then adjusting the gates of the powerhouse until the required flow passing through the number of powerhouse units in operation maintained the correct headwater elevation. The spillway gates were calibrated by setting the correct river discharge entering the model, setting the powerhouse gates to pass the correct discharge for the given river discharge condition, setting the spillway gates to the correct opening sequence as prescribed in the Kentucky spillway discharge tables, dated December 1948, and using the original spillway gate arrangements that were to be used in the prototype starting in January 1999 (provided by TVA), and then adjusting the tailgate at the end of the model to maintain the correct tailwater elevation.

A time-lapse videotape recorder and camera were installed on the downstream island-side guide wall at the prototype site to monitor tow traffic entering and exiting the existing lock from January through September 1999. This information was then used to compare to model data taken from tows making similar

passages entering and leaving the lock under similar flow conditions. The comparison of the videotapes to the model operations of the tow indicates navigation conditions are reproduced with a reasonable degree of accuracy. Also, representatives of the navigation industries that use Kentucky Lock visited the model, observed operations of the model tow with various flow conditions, and validated, based on their navigation experiences at the site, the model represented navigation conditions for the flow conditions reproduced to an acceptable degree of accuracy.

3 Model Experiments and Results

Experimental Procedures

The initial flow conditions that the Nashville District requested to be documented for the base conditions were 35,000, 70,000, 80,000, 125,000, and 370,000 cfs. During meetings with the Nashville District, navigation industry representatives, and TVA officials on 20 August 1999, it was determined that maximum powerhouse flow actually ranged up to 80,000 cfs instead of the 60,000 cfs that was discussed during preconstruction meetings in August 1998. This required all flow conditions that exceed the maximum powerhouse flow to be recalibrated and redocumented. At the same time, the 70,000 flow with the high (313.5 ft) tailwater was not considered a critical condition by the towing industry and was dropped from further consideration. The industry suggested looking at a flow condition between 125,000 and 370,000. Time-lapse videography demonstrated there were obvious navigation difficulties at 300,000 cfs with a tailwater of 328.0 ft. Industry suggested that this flow condition be added for model documentation.

The Nashville District requested that the U.S. Army Engineer Research and Development Center (ERDC) evaluate navigation conditions for the 100,000-, 125,000-, and 150,000-cfs flows to determine which flow condition was more difficult for navigation. After preliminary evaluation, the 100,000-cfs flow was determined to be more difficult for navigation and was added to the list of flow conditions to be used for model evaluations.

The flow conditions used for documentation and evaluation of base conditions were as follows:

Discharge, cfs	Headwater, ft	Tailwater, ft
35,000	359.0	300.0
79,000	359.0	303.6
100,000	358.0	306.3
300,000	362.5	328.0
370,000	368.3	344.0

To document the navigation conditions, current directions and velocities and tow tracking were performed. Current directions and velocities are obtained by tracking of lighted floats, weighted to draft 9 ft, throughout the model by means of video tracking equipment mounted over the model. The cameras of the video tracking system are calibrated to provide a north and east state plane coordinate and a time stamp for each light. Velocities and directions are calculated using the total distance traveled by an individual light and the total time the light took to travel over a specified interval. This information was provided as velocity vector plots, showing the direction of the current and listing the magnitude of the current. Tracking of the tows was also performed with the video tracking system. Lights were placed on the center line of a 15-barge tow, 50 ft from the head of the tow and 125 ft from the rear of the barge string, leaving 800 ft between the lights. The tow was maneuvered through the channel as the tracking system was operated. The tracking system again records the position and time-step of the two lights mounted on the tow. This information was later processed to provide the position of the tow and its speed and heading. This information was provided as a plot, showing the position of the tow at specified intervals during its transit, along with the average speed of the tow over the specified interval in feet per second, and the angle of the center line of the tow in relation to the center line of the existing lock.

A radio-controlled towboat and barges were used to evaluate and demonstrate the effects of currents on navigation. The towboat was equipped with twin screws, Kort nozzles, forward and reverse rudders, and powered by two small electric motors operating from batteries in the tow. The speed of each engine and direction of the rudders were remotely controlled and the towboat could be operated in forward and reverse at speeds comparable to those that could be expected of typical tows in the study reach. The tow used in the study represented a makeup of fifteen 195-ft-long by 35-ft-wide standard barges, with a 100-ft pusher. This provided an overall size tow of 1,075 ft long by 105 ft wide loaded to a draft of 9 ft. The model towboat provided an accurate representation of the maneuvering characteristics of prototype towboats based on comparisons with the time-lapse video recorded in the prototype and discussions with pilots. Pilots later confirmed this when they viewed the model and operated the model towboat. The towboat was calibrated to the speed of a comparable size prototype towboat moving in slack water and was powered to operate at 1 to 2 mph above the speed of the currents to maintain rudder control but not overpower the currents. A model tow does not have a specific horsepower rating but was controlled to provide only enough power to keep the tow moving at a speed sufficient to maintain rudder control.

As part of the documentation of the baseline conditions, a video camera was mounted over the spillway and powerhouse and connected to a video recorder. Dye was injected through each of the powerhouse turbine units and through spillway gates to demonstrate how the flow from the powerhouse was mixing with the spillway and to show recirculation patterns. Paper confetti was also used to help visualize eddy patterns and recirculation.

To obtain point velocities near proposed bridge piers, training works, spillway eddy reduction works, and near the channel bottom, an Acoustic Doppler Velocity (ADV) meter was used. The meter sends out an acoustic signal

obliquely to the probe, which was reflected by minute particles or a seeding material in the water back to the probe sensors. The shift in the reflected acoustic signal can than was used to determine two-dimensional (2-D) velocities. The resultants of the 2-D (x and y) velocities yield the magnitude and direction of the velocities. The specifications state that the probe can be used to record velocities to within 3 mm vertically above an object and within 5 mm of the water surface.

A critical flow condition that had been associated with increased fish mortality downstream of the spillway was selected for documentation. This flow condition, 155,000 cfs with a headwater el of 359.0 and a tailwater el of 316.0, was selected for documentation after discussion with officials from KDWFR. This condition was examined with current directions and velocities, point velocities using an ADV meter, and visualizations using dye and confetti patterns. This flow condition was not evaluated for navigation during documentation of the existing conditions.

Base Experiments (Existing Conditions)

Description

Base experiments were conducted with the model reproducing existing conditions as shown in Figure 3 and Photo 3. The purpose of conducting these evaluations was to verify that the model was reproducing known prototype conditions and provide information and baseline data that could be used to evaluate the effect of the proposed modifications on water-surface elevations, current direction and velocities, and navigation conditions. The principal features reproduced in the model, as shown in Figures 3-5, include the following:

a. The 24-gate dam, with a sill elevation of 325.0 and each gate 40 ft wide with three leafs, two18-ft leafs on bottom and one 14- ft leaf.

b. The five-turbine hydropower plant, each turbine unit capable of passing 16,000 cfs with a 60-ft head, adjacent to the right side of dam.

c. The powerhouse island which separates the powerhouse from the lock.

d. The 600-ft by 110-ft lock with an upper sill elevation of 334.8, lower sill elevation of 289.75, and the top of lock elevation of 382.0.

e. The downstream riverward solid guide wall, 496 ft long, and the downstream landward solid angled guide wall, 226 ft long.

f. The I-24 bridge piers, approximately 1 mile downstream of the axis of the dam with a navigation span of 525 ft.

g. The two 32-ft-diam mooring cells immediately downstream of the powerhouse island and the two 40-ft diameter mooring cells on the left descending bank line with the most upstream cell approximately 2,450 ft from the center line of the I-24 bridge

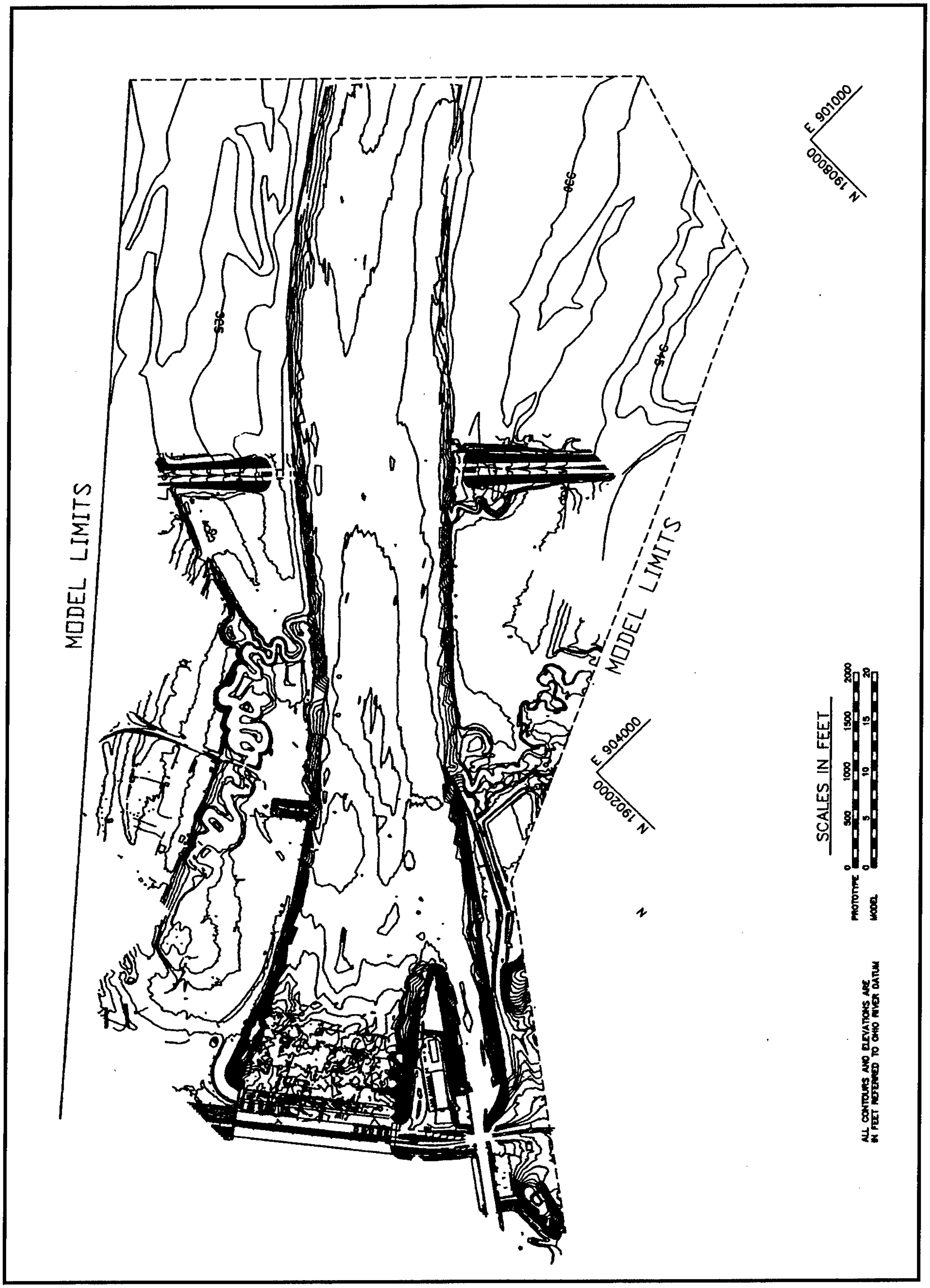


Figure 3. Base conditions

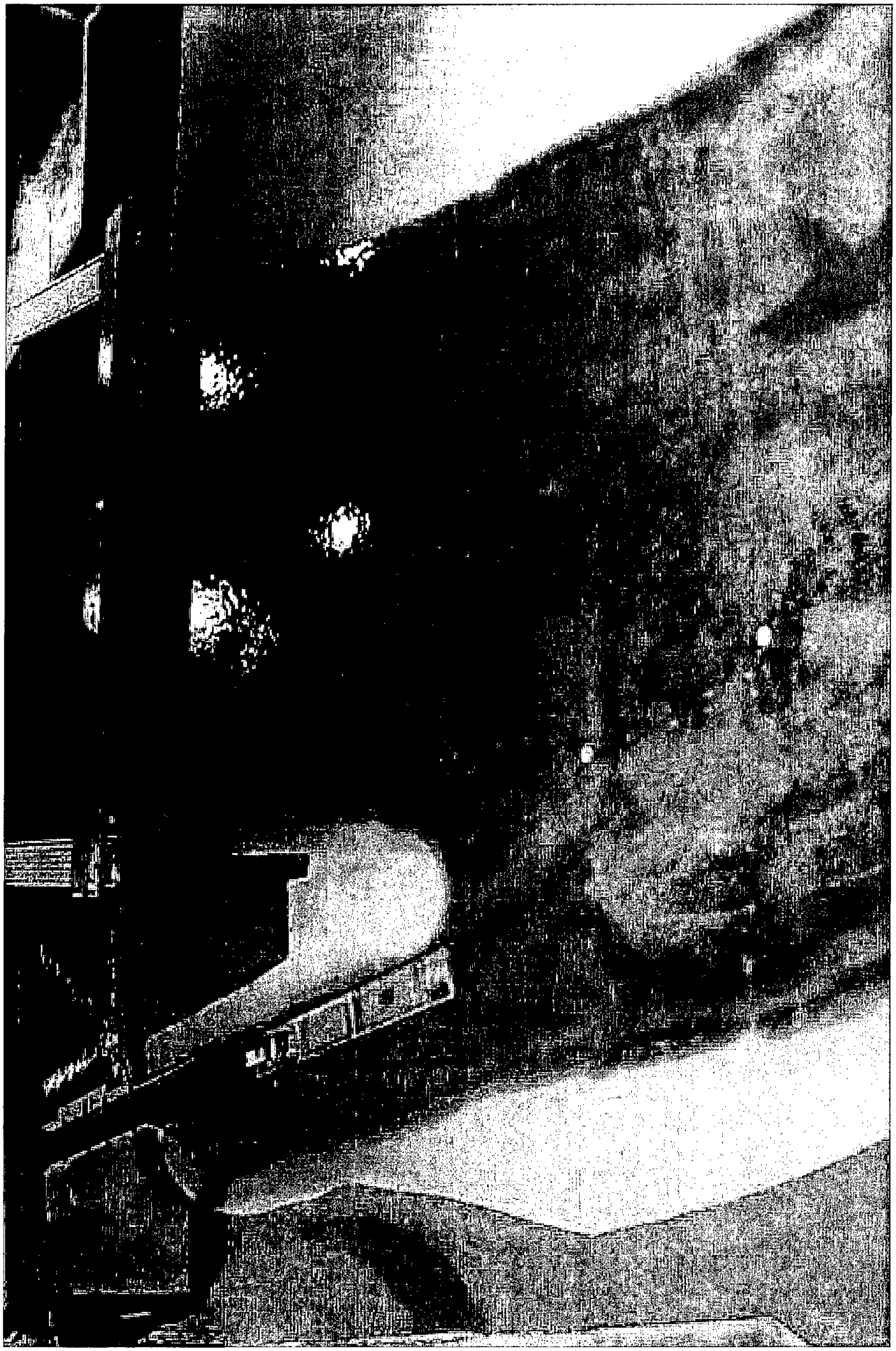


Photo 3. Kentucky Lock and Dam model

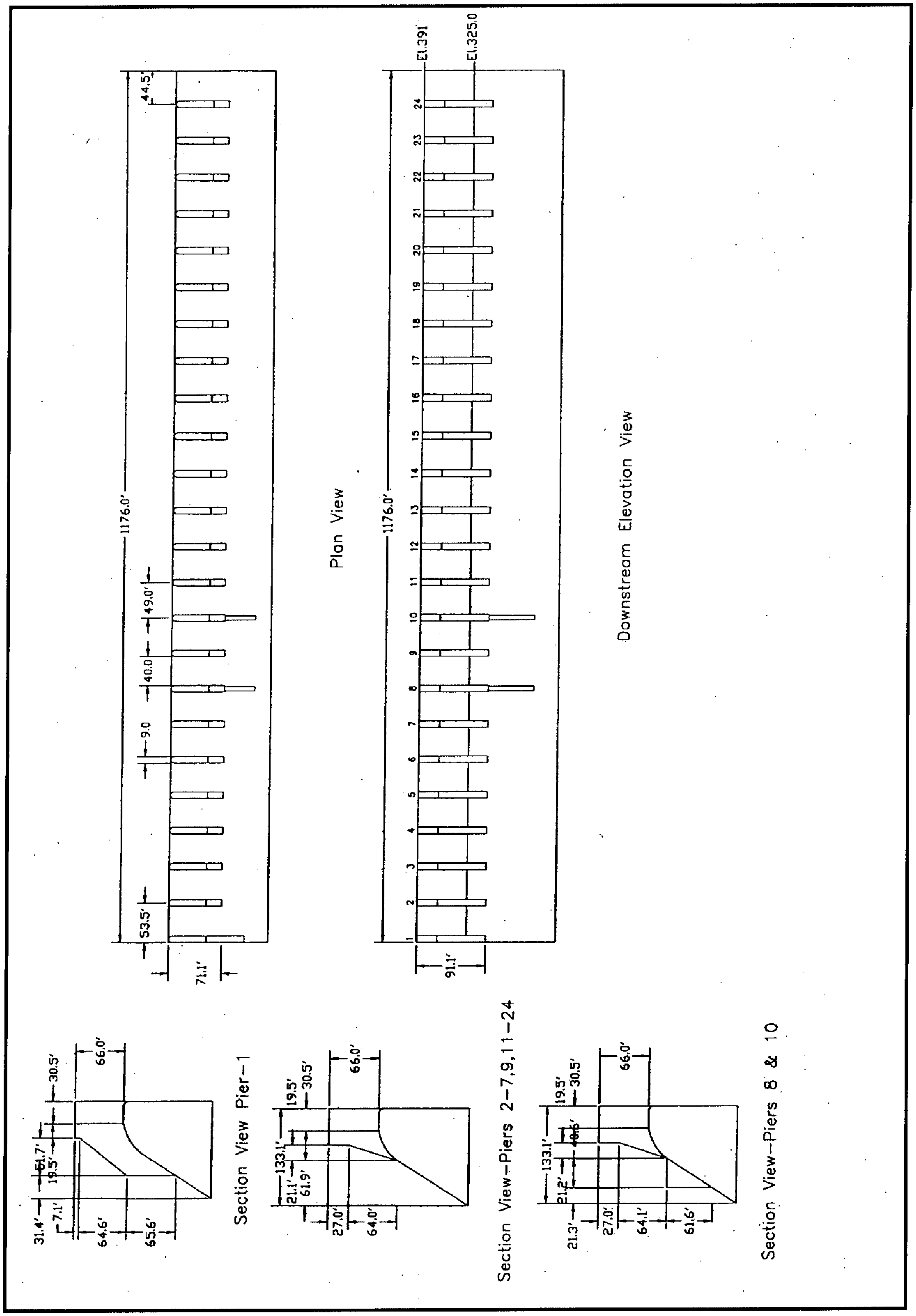


Figure 4. Existing conditions, dam

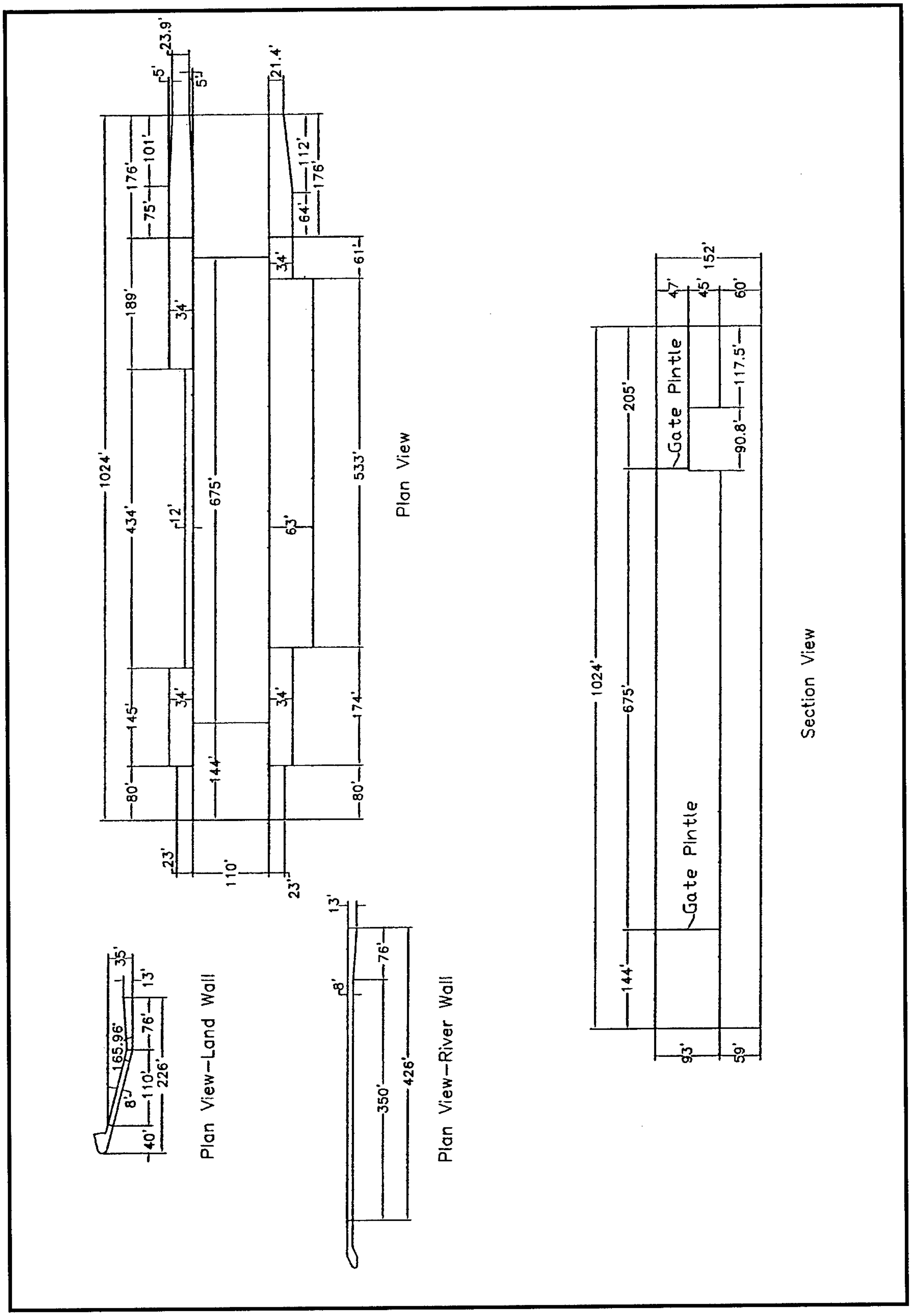


Figure 5. Existing conditions, lock and guide walls

h. Seven piers that were used to support the railroad bridge prior to construction of the dam, with the pier immediately downstream of the powerhouse along the west side of powerhouse island at el 304.0 and the remaining piers roughly cut off at el 290-295.

Results, navigation conditions

Current directions and velocities. Current directions and velocities are shown in Plates 1-6. For the 35,000-, 79,000-, and 100,000-cfs flow conditions (Plates 1-3), the currents generally were parallel to the alignment of the channel. As the flow increased, there was more flow that moved along the powerhouse island and crossed into the lower lock approach. The clockwise eddy just downstream of the end of the powerhouse island increased in both size and speed with the increase of flow. With the 100,000-cfs flow condition (Plate 3), currents moved at a sharper angle to the center line of the lock, especially between the two mooring cells immediately downstream of the powerhouse island. For the 155,000-cfs flow condition (Plate 4), flow tended to start turning toward the right descending bank line as it passed the end of the powerhouse island. For the 300,000-cfs flow condition (Plate 5), there was strong flow off the end of the island and between the mooring cells toward the right bank. The eddy in the lock approach was reduced in size and pushed closer in toward the lock. With the 370,000-cfs condition (Plate 6), the direction of the currents across the lock approach was about the same as with the 300,000-cfs condition, but the magnitudes of the currents were less. Currents through the rest of the channel were generally parallel to the bank lines for both flow conditions with velocities with the 370,000-cfs flow condition being somewhat lower than with the 300,000-cfs condition. The velocities at approximately one tow length downstream of the end of the powerhouse island ranged from 1.8 to 3.3 fps with the 35,000-cfs flow, 1.9 to 6.3 fps with the 79,000-cfs flow, 2.3 to 6.4 fps with the 100,000-cfs flow, 3.6 to 5.1 fps with the 155,000-cfs flow, 3.6 to 5.8 fps with the 300,000-cfs flow, and 1.5 to 4.4 fps with the 370,000-cfs flow.

In examining the navigation conditions with the model tow, numerous transits are made in each direction with each flow condition. The tracks that are presented in the plates for this report are representative examples of a typical transit for the given direction and flow condition.

Tow tracks, downbound. 35,000 cfs - The downbound track (Plate 7) showed that the tow can be turned into the current off the end of the mooring cells without any significant difficulty and get into alignment to pass through the bridge approximately two tow lengths before reaching the bridge. A slight set toward right bank was noted as the tow reached the mooring cells.

79,000 cfs - For the downbound track (Plate 8), there was a slight set toward the right bank as the tow passed just downstream of the mooring cells. It was still not difficult to get the tow out into the channel and aligned to pass through the navigation span by 1½-tow lengths from the bridge.

100,000 cfs - For the downstream track (Plate 9), there was no difficulty in getting off the guide wall. As the head of the tow approached a point near

midway of the mooring cells, a strong set toward the right bank became apparent. Left rudder was applied to turn the tow into the current, forcing the stern of the tow toward the right bank. As the stern got near the right bank, the rudder had to be brought to nearly midship to keep from grounding the stern in the bank. The tow steadily drifted downstream laterally with the head of the tow still not out into the channel sufficiently to clear the bridge pier on the right side of the navigation span. The tow rapidly accelerated as it got out into the current as the stern of the tow passed the downstream mooring cell. As the tow approached the point on the right bank about 3,000 ft downstream of the lower lock gate pintel, the tow lost most of the lateral set and started moving out into the channel. As soon as the head of the tow was channelward enough to clear the right pier, the tow had to be steered hard right to bring the stern around to clear the pier. The stern got out far enough to clear the pier just as the head of the tow passed through the navigation span. Almost all the runs passed through the navigation span well toward the right side of the navigation span. Navigation downstream of the bridge was not difficult.

300,000 cfs - With the downbound track (Plate 10), getting off the guide wall and out along the powerhouse island was not difficult. As the head of the tow came alongside the most downstream mooring cell, the current set the tow strongly toward the right bank. The tow must be steered hard left as long as possible without hitting the stern on the bank line to push the head out into the channel. The tow moved more laterally than forward until the head of the tow passed the most upstream left bank mooring cell. After this point, the tow started gaining longitudinal momentum and the head came out far enough into the channel to clear the right navigation span pier. The tow could then be steered hard right to get it into alignment to pass through the bridge. The tow got into alignment with less than one tow length from the bridge. The higher velocities and the stronger lateral set made this condition more difficult than with the 100,000-cfs flow condition. Passage downstream of the bridge was not difficult.

370,000 cfs - For the downstream track (Plate 11), getting off the guide wall and out along the powerhouse island was not difficult. As the tow got alongside the opening between the two mooring cells, it experienced a modest set toward the right bank. This set was not quite as strong as with the 100,000-cfs flow condition, and was dissipated about one tow length downstream of the last mooring cell. It was not difficult, after that point, to get the head of the tow out into the channel and get into alignment to go through the bridge. Passage through the bridge and downstream of the bridge was not difficult.

Tow tracks, upbound. 35,000 cfs - The upbound track (Plate 12) showed little difficulty. There was a slight set noted toward the right bank as the tow got alongside the mooring cells and immediately downstream of the cells.

79,000 cfs - With the tows moving upbound (Plate 13), there was little difficulty in making the transit. As the tow approached the mooring cells and was slowing to enter the lock, there was a slight set toward the right bank, but nothing of any concern.

100,000 cfs - The upbound track (Plate 14) was similar to the lower flow conditions and showed little difficulty. Navigation from the end of the model to

well upstream of the bridge was not difficult. The approach that appeared to work best for this flow was to steer more or less parallel with the currents until the head of the tow was about one tow length from the most downstream mooring cell. By then turning the tow slightly toward the left, the currents helped push the head of the tow toward the right descending bank line. With the lower flow conditions the tow could be steered more directly across the slower currents. The tow accelerated as it got into the slower currents between the right bank and the mooring cells and engine power had to be reduced. As the tow came into alignment with the lock approach, adjacent to the mooring cells and slowing, the tow had to be steered slightly left to hold the stern from being pushed into the right descending bank and to keep the head of the tow from rotating to the right and into the powerhouse island. Once the stern of the tow was about halfway between the two mooring cells, the effect of the crosscurrents was diminished. Approaching and entering the lock from this point was not difficult.

300,000 cfs - With tows moving upbound (Plate 15), coming from the end of the model to immediately upstream of the bridge was not difficult. It was not difficult to work the tow over toward the right descending bank line to make the approach toward the lock. At a point slightly less than one tow length from the downstream most mooring cell, the tow could be turned slightly to the left and the head of the tow would come landward of the mooring cells with little difficulty. As the tow reached the mooring cells, the set toward the right descending bank line was noticed but was not difficult to overcome. The stern must be steered into the current to keep the stern from being driven into the right descending bank line. As the stern of the tow passed about midway between the mooring cells, the current effect was almost totally gone. The approach into the lock was not difficult.

370,000 cfs - The upbound track (Plate 16) showed that coming from the end of the model to upstream of the bridge was not difficult. It was not difficult to work the tow over toward the right descending bank line to make the approach toward the lock. At a point slightly less than one tow length from the downstream most mooring cell, the tow could be turned slightly to the left and the head of the tow would come landward of the mooring cells with little difficulty. As the tow reached the mooring cells, the set toward the right descending bank line was slightly noticeable but was not difficult to overcome. Some small amount of left rudder must be applied to keep the stern from being pushed toward the right descending bank line. As the stern of the tow passed about midway between the mooring cells, the current effect was almost totally gone. The approach into the lock was not difficult. Acceleration of the tow as it passed the mooring cells was almost totally absent as compared to the other flow conditions examined.

Navigation conditions for upbound tows are generally not excessively difficult for any of the flow conditions examined. Navigation conditions for downbound tows are not difficult at the 35,000- and 79,000-cfs flow conditions. Downbound navigation conditions at 100,000 cfs are moderately difficult, more difficult at 300,000 cfs, and somewhat less difficult at 370,000 cfs as compared to the 300,000-cfs condition.

Results, mixing, recirculation, and water column velocities

The video tracking system was used with the 9-ft draft floats to obtain velocities and direction of the eddies that form below the spillway. These velocities and directions were recorded as baseline conditions to compare to those obtained during evaluation of the various plans that are to be examined in the model.

Gas entrainment into the water in a spillway was directly related to the distance that the water falls as it comes through the gates of the dam and falls to the stilling basin. (Personal Communication, Dr. Steve Wilhelms, research hydraulic engineer, Environmental Hydraulics Group, Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, MS.) In the case of Kentucky Dam, the design of the dam gates (leaf gates that flow passes over instead of under) and the deep stilling basin (approximately 85 ft below the sill of the dam) means that the gas entrainment was high. The operation of the powerhouse and spillway gates, which concentrates flow along the right side of the channel at low to moderate discharges, tends to create a counterclockwise eddy below the spillway. Water that makes up this eddy was stagnant and cannot dissipate the gas within it. This flow, as it returns back to the stilling basin, entrains even more gas with leads to higher gas saturation levels than the water can normally retain, which was called supersaturation. In some spillway and tailrace designs, flow from the powerhouse tailrace which typically has low levels of gas saturation can be pulled into the spillway and have its gas saturation levels increased. High gas saturation levels are associated with increased fish mortality. The large area covered by these eddies with high gas saturation levels as compared to the small area covered by the even higher gas saturation levels in the stilling basin lead to the high fish mortality.

The 35,000-cfs flow (Plate 1) showed a large, slow counterclockwise eddy formed below the spillway. With the 79,000-cfs flow (Plate 2), the eddy was about the same size as with the 35,000, but moved considerably faster. With the 100,000-cfs flow (Plate 3), the eddy was slightly smaller but just as fast as with the 79,000-cfs flow. With flow coming through the first three spillway gates, the water recirculating in this eddy kept mixing with the spillway flow, indicating an increase of gas saturation level in the eddy. With the 155,000-cfs flow (Plate 4), the eddy was decreased in size and pushed to the left bank. Flow from the eddy moved back into the stilling basin and mixed with the high gas saturated flow in the stilling basin. The 300,000-cfs flow (Plate 5) had flow all the way across the spillway. Even so, there was a small, counterclockwise eddy that was formed about mid length of the spillway and extended down to the old railroad cells. By holding water and moving it back into the stilling basin, this area was also more likely to have high gas saturation level. With the 370,000-cfs flow (Plate 6), there was flow completely across the spillway and there was no sign of any recirculation below the spillway.

Videos made while dye was injected through the spillway and powerhouse gates for the various flow conditions indicated that there was no significant mixing of powerhouse and spillway discharge near the stilling basin at any of the flow conditions examined. There was no indication of flow being pulled from the powerhouse tailrace toward the stilling basin. Mixing of the spillway and

powerhouse flow did not appear to be a significant factor in either increasing or decreasing gas saturation levels for the flow conditions evaluated.

Plan A – Installation of Proposed 1,200-ft Lock

Description

After completion of base condition evaluations, the proposed 1,200-ft lock and 1,200-ft solid landward guide wall were installed in the model (Plan A) (Figure 6 and Photo 4). At this time, the design of the proposed highway and railroad bridge piers had not been finalized and therefore they could not be fabricated and installed in the model. The schedule for prototype construction calls for the bridge piers to be constructed and in place prior to completion of the proposed lock and guide wall. During the completion of the final design of the bridges the model was used to obtain preliminary evaluations with just the proposed lock in place. As part of the project, the two 32-ft-diam mooring cells immediately downstream of the powerhouse island are to be removed.

The principal features of Plan A were as follows (Figures 6 and 7):

a. A 110-ft wide by 1,200-ft-long lock chamber, landward of the existing lock with an upper sill elevation of 335.0, lower sill elevation of 285.0, and the top of lock elevation of 382.0.

b. A 1,200-ft-long solid guide wall extending downstream from the landside of the lock.

c. Removal of the two 32-ft mooring cells immediately downstream of the powerhouse island.

Results

The operation of the proposed lock as evaluated for Plan A will not be constructed in the prototype prior to the construction of the proposed highway and railroad bridges. Since this operational condition will not exist in the prototype, evaluations of this plan are not documented in this report. Operation of the model with this plan did provide useful insight into how navigation conditions could change as compared to base conditions and what flow conditions and areas of the study reach could be potential problems once the final post project plan was installed.

Plan B – Proposed 1,200-ft Lock, Highway and Railroad Bridges

Description

Upon completion of the final design for the highway and railroad bridge piers, they were fabricated and installed in the model with the proposed 1,200-ft

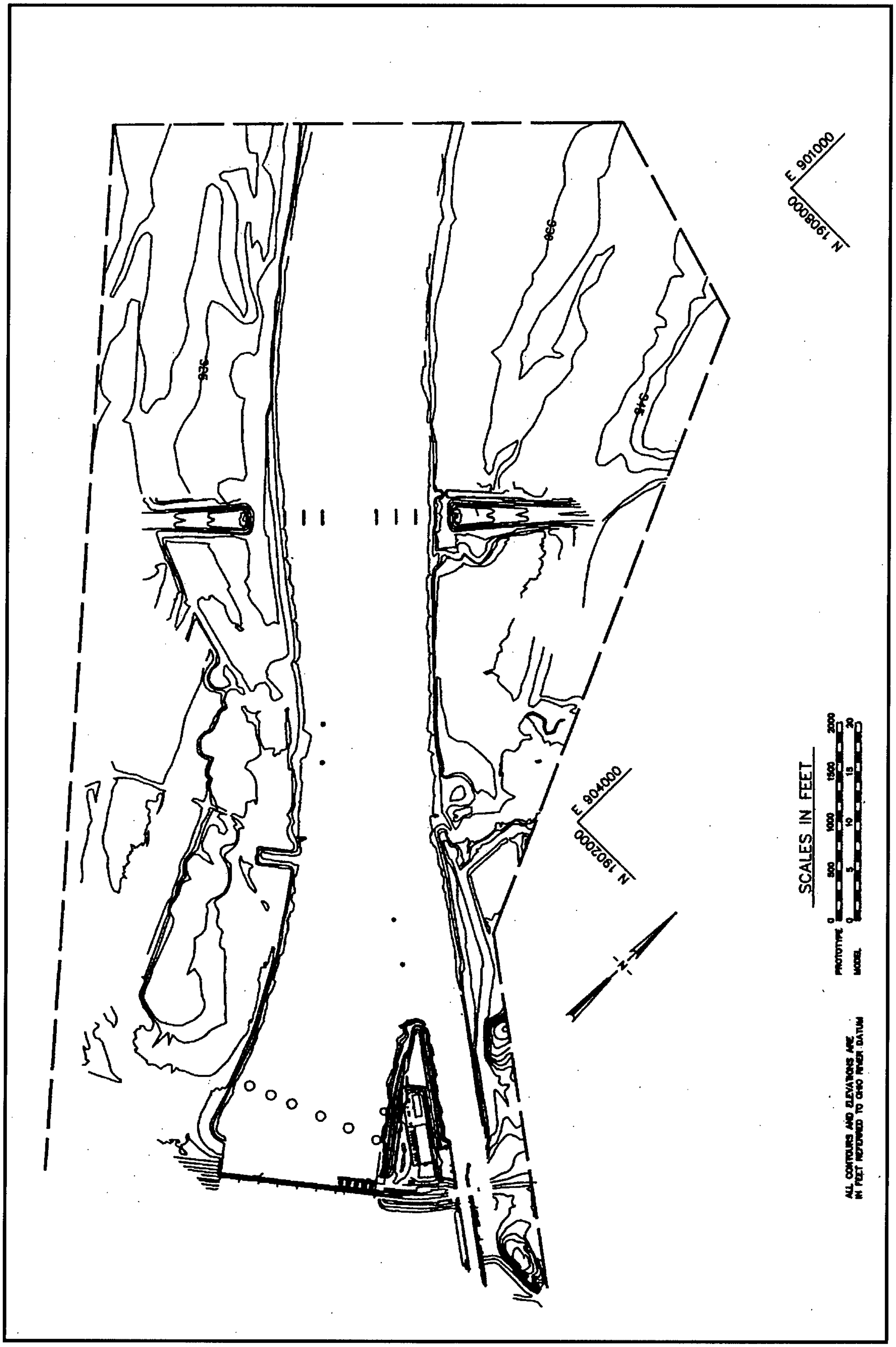


Figure 6. Plan A conditions

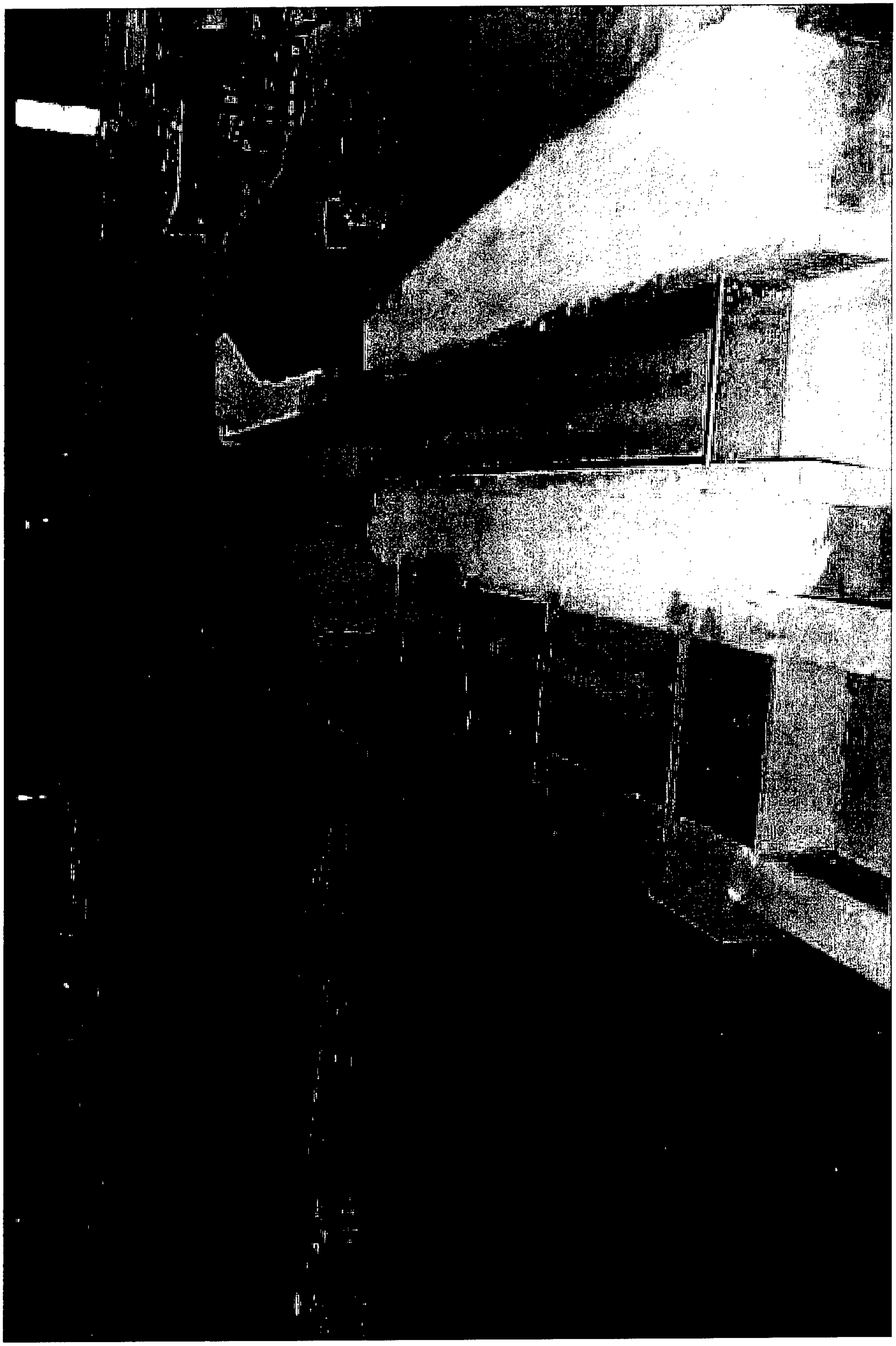


Photo 4. Proposed 1,200-ft lock and guide wall, Kentucky Lock and Dam model

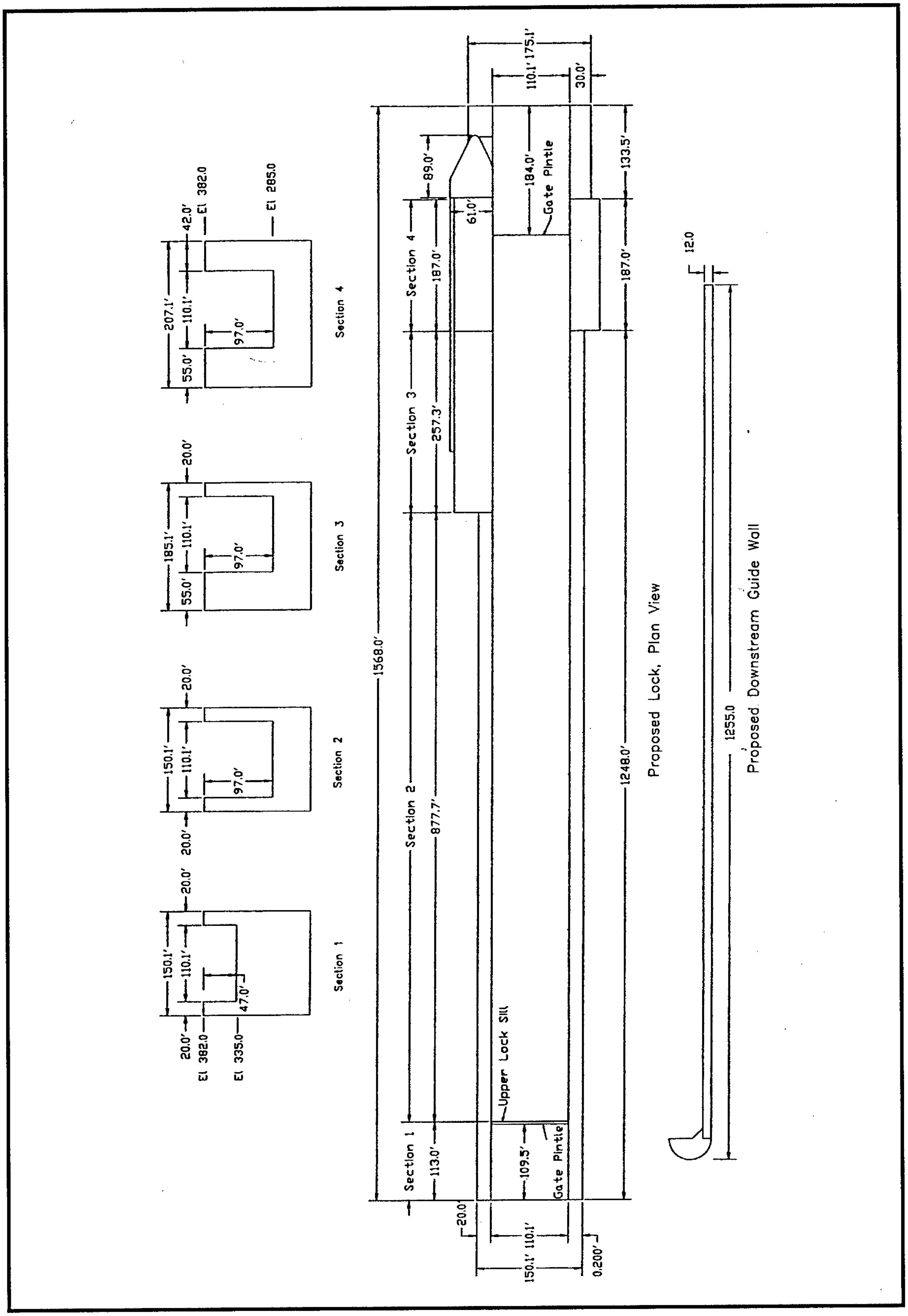


Figure 7. Proposed 1,200-ft lock and guide wall

lock and 1,200-ft downstream guide wall. This was designated as Plan B (Figure 8).

The principal features of Plan B were as follows (Figures 8-10):

a. A 110-ft wide by 1,200-ft-long lock chamber, landward of the existing lock with an upper sill elevation of 335.0, lower sill elevation of 285.0, and the top of lock elevation of 382.0.

b. A 1,200-ft-long solid guide wall extending downstream from the landside of the lock.

c. Removal of the two 32-ft mooring cells immediately downstream of the powerhouse island.

d. The proposed highway piers (Figure 9), spaced 304 ft on center with four 6-ft pilings and a 36-ft-diam pier cap for each pier, with the elevation at the bottom of the pier cap of 300.0.

e. The proposed railroad piers (Figure 10), 100 ft downstream between center lines of the highway bridge to the railroad bridge, piers at 152-ft spacing on center, with four 7-ft pilings and a square pier cap of 27 ft at the base with the bottom of the pier cap at 300.0.

Results, navigation conditions

Current directions and velocities. Current directions and velocities are shown in Plates 17-22. For the 35,000-cfs flow conditions (Plate 17) the currents were generally aligned with the bank lines and a large, but slow eddy formed in the lock approach. The velocities about one tow length downstream of the end of the guide wall were generally from 2.0 to about 3.0 fps. With the 79,000-cfs flow (Plate 18) the currents were again generally parallel to the bank lines and the eddy in the lock approach was elongated downstream and was slightly stronger. Velocities at one tow length from the end of the guide wall ranged from about 1.6 to slightly greater than 5.0 fps. For the 100,000-cfs flow (Plate 19) the currents were generally aligned with the bank lines and the eddy in the lock approach had become much wider, taking the full width of both lock approaches, and had a maximum velocity of 0.9 fps. The velocities at one tow length from the end of the guide wall were from 3.2 to 5.7 fps. For the 155,000-cfs flow (Plate 20) the currents were generally aligned with the bank lines and the width of the downstream end of the eddy in the lock approach had been compressed as compared with the previous flow and the maximum velocity on the right descending bank line immediately downstream of the end of the guide wall was 1.1 fps. The velocities at one tow length downstream of the end of the guide wall were from 3.7 to 6.3 fps. For the 300,000-cfs flow (Plate 21) the currents were again parallel to the bank lines, except that the angle the currents are moving across the lower lock approach was greater than with the lower discharge flow, reducing the length of the eddy in the lock approach, but maintaining a maximum velocity of 1.1 fps moving upstream along the right descending bank line about 500 ft downstream of the end of the guide wall. The velocities at one tow length downstream of the end of the guide wall were from 4.6 to 5.7 fps. For the 370,000-cfs flow (Plate 22) the flow moved out onto the overbanks but generally tended to follow

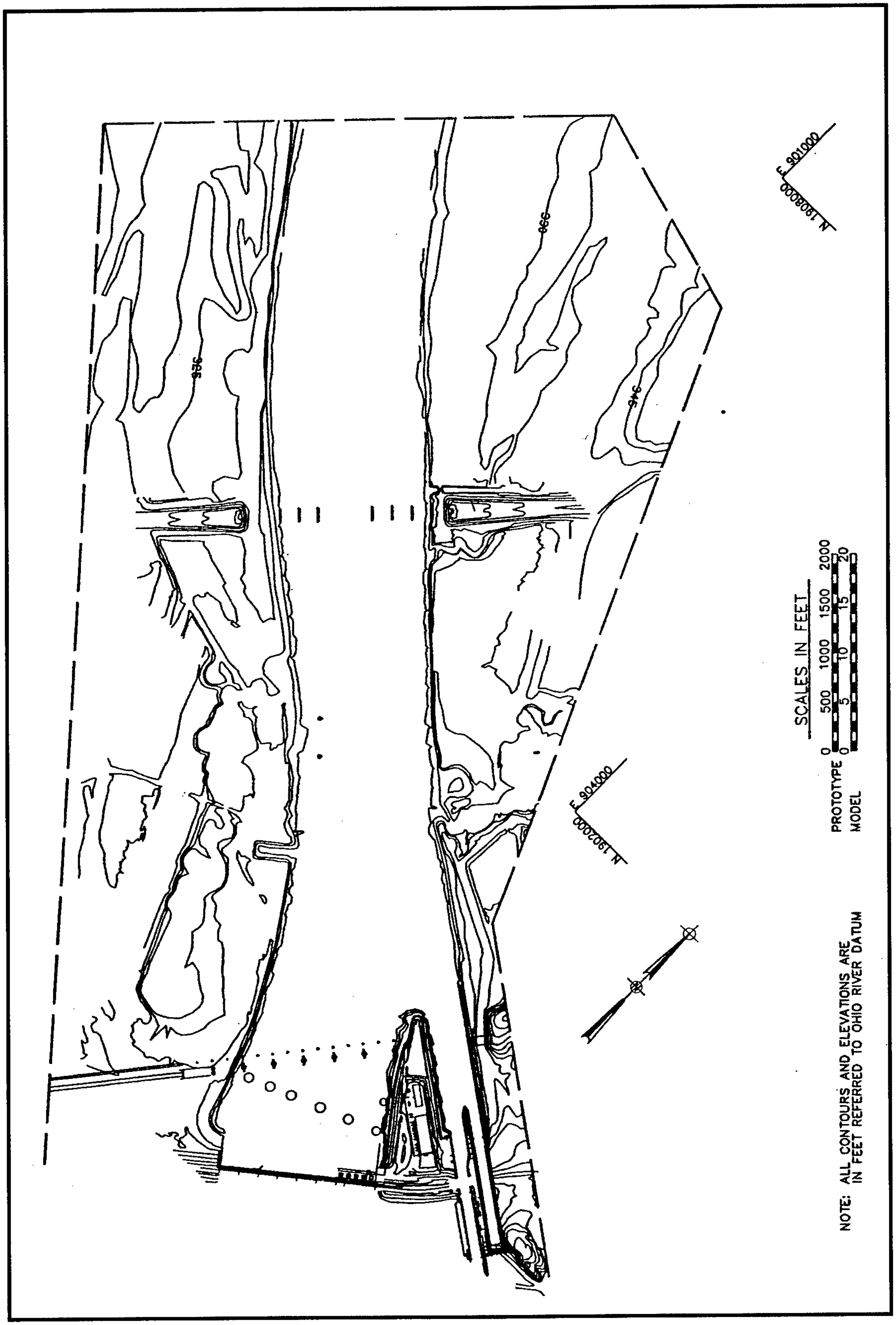


Figure 8. Plan B conditions

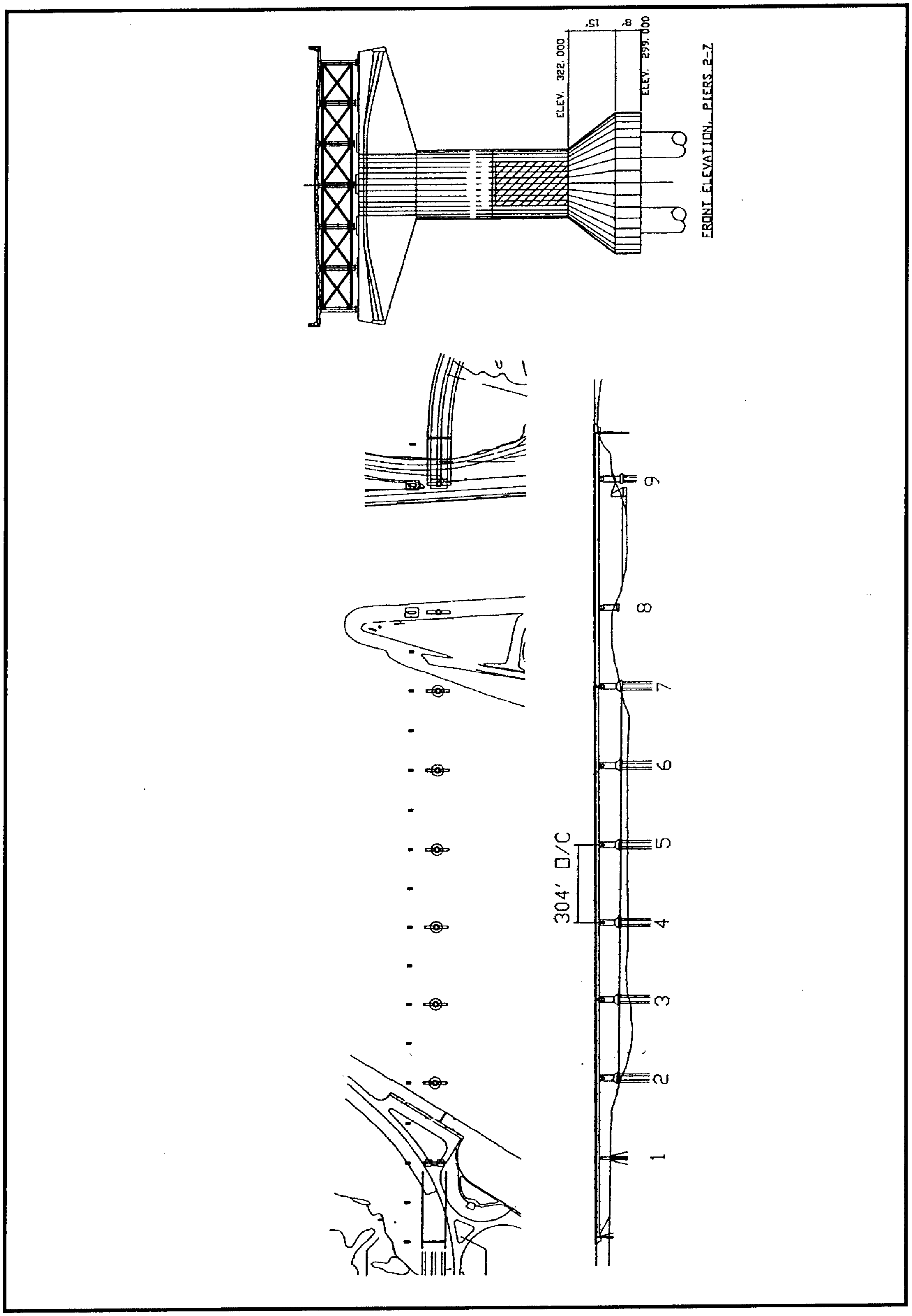


Figure 9. Proposed highway bridge

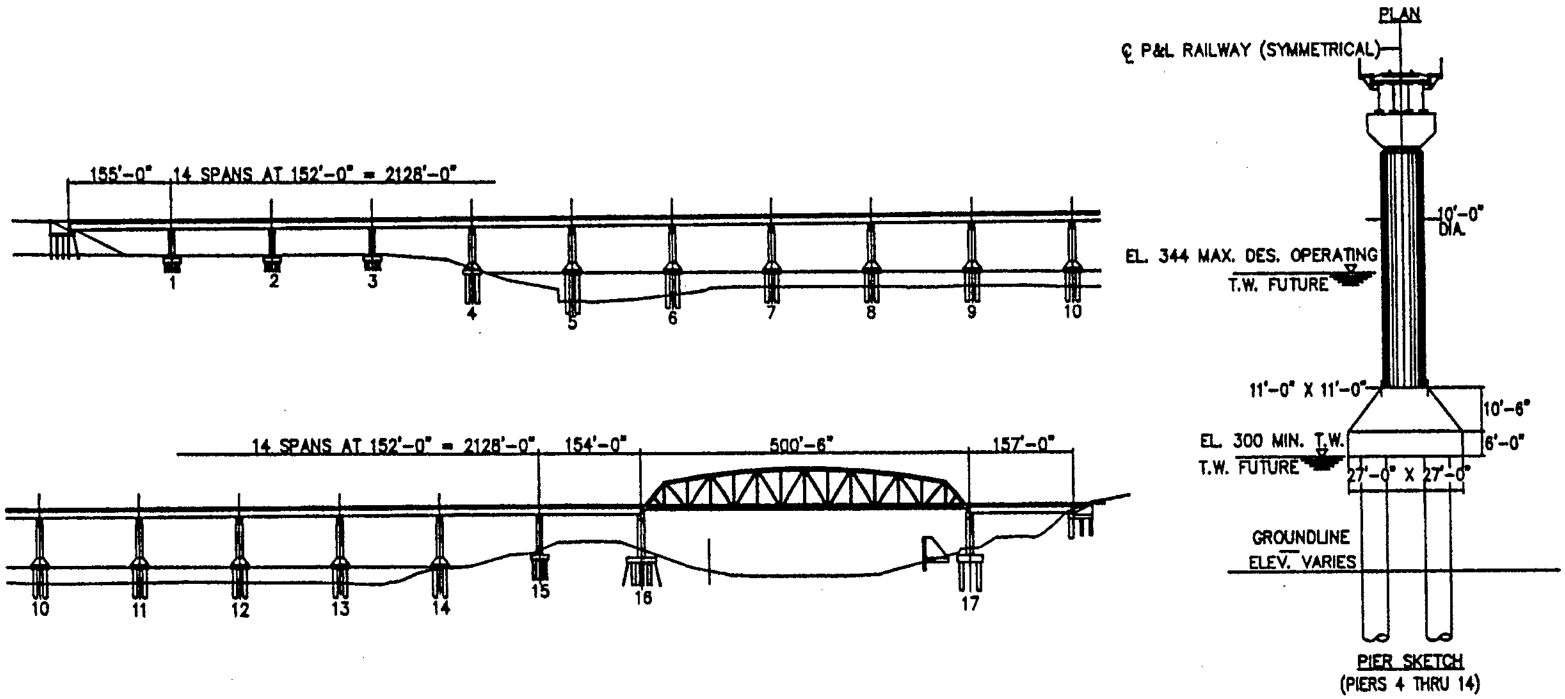


Figure 10. Proposed railroad bridge

the bank lines. The angle that the currents moved across the lock approach was slightly less than with the 300,000-cfs flow condition and flow across the end of the powerhouse island had reduced the size of the eddy. The maximum velocity was 1.3 fps at the end of the guide wall. The velocities at one tow length from the end of the guide wall ranged from 3.0 to 5.0 fps.

Tow tracks, downbound. 35,000 cfs – There was no difficulty in getting off the guide wall (Plate 23). There were no apparent crosscurrents until the head of the tow got about one tow length downstream of the end of the guide wall. A slightly stronger set as compared with base conditions was noted as the head of the tow reached approximately one and one-half tow lengths downstream of the guide wall. There was no difficulty in getting the tow out into the channel or getting through the bridge and downstream to the end of model.

79,000 cfs - There was no problem getting out of lock and alongside the guide wall (Plate 24). The clockwise eddy near the end of the guide wall helped the head of tow separate from the guide wall. Once a sufficient angle of the tow in relation to the guide wall was achieved to allow the tow to get out into the current, the tow could be brought ahead and started out into the channel. A slight set was noted as the head of the tow reached approximately one and one-half tow lengths downstream of the guide wall, but nothing significant. Getting out into the channel was no more difficult than with base conditions after a sufficient angle was obtained on the tow before starting away from the guide wall.

100,000 cfs - The tow was moved slowly out along the guide wall (Plate 25). The clockwise eddy helped separate the head from the guide wall. By allowing the current to turn the head and steering away from the wall, the tow could get sufficient angle to move out into the current. The current set at about one and one-half tow lengths downstream of the guide wall was much stronger than with the 79,000-cfs flow, making it more difficult to get out into the channel and into alignment with the navigation span. The set was manageable and the tow was able to get out into the channel and aligned to pass through the bridge from one to 1.5 tow lengths from the bridge.

300,000 cfs - Getting off the guide wall and out along the powerhouse island was not difficult (Plate 26). The eddy in the lock approach helped separate the head from the wall and getting sufficient angle to get out into the current was not a problem. As the tow got about two tow lengths downstream of the guide wall, it experienced a moderate set toward the right bank. This set was dissipated about three tow lengths downstream of the end of the proposed guide wall. It was not extremely difficult, after that point, to get the head of the tow out into the channel and get alignment to go through the bridge. Passage through the bridge and downstream of the bridge was not difficult.

370,000 cfs - Getting off the guide wall and out along the powerhouse island was not difficult (Plate 27). The eddy in the lock approach was not as strong so it required more torquing of the tow to rotate the head off the wall. As the tow got about one tow length downstream of the end of the guide wall, it experienced a modest set toward the right bank. The set was dissipated about three tow lengths downstream of the guide wall. It was not difficult, after that point, to get the head

of the tow out into the channel and into alignment to go through the bridge. Passage through the bridge and downstream of the bridge was not difficult.

Tow tracks, upbound. 35,000 cfs - There was no difficulty in coming from the end of the model to well upstream of the bridge (Plate 28). The approach to the lock was almost straight with little noticeable set. Some set was noticed when the head of the tow was within about one tow length of the lower end of the guide wall and the tow was slowed coming into the lock approach. The set was not strong and was easy to correct for. Getting the tow onto the guide wall and into the proposed lock was not difficult.

79,000 cfs – Navigation conditions (Plate 29) were similar to those with the 35,000-cfs flow. The only noticeable set was when the head of the tow got to within one tow length from the lower end of the guide wall and was slowing for the approach. Getting onto the wall and into the lock was not difficult.

100,000 cfs – Navigation from the end of the model to well upstream of the bridge was not difficult (Plate 30). The approach that appeared to work best was to steer more or less parallel with the currents until the head of the tow was about two tow lengths from the downstream end of the guide wall. By then turning the tow slightly toward the left, the currents helped push the head of the tow toward the right descending bank line. The tow accelerated slightly as it got into the slower currents less than one tow length from the guide wall and engine power had to be reduced. There was no significant difficulty to get the tow alongside the guide wall and enter the lock.

300,000 cfs – Coming from the end of the model to immediately upstream of the bridge was not difficult (Plate 31). It was not difficult to work the tow over toward the right descending bank line to make the approach toward the lock. At a point slightly less than two tow lengths from the downstream end of the guide wall, the tow could be turned slightly to the left and the head of the tow would come landward of the mooring cells with little difficulty. As the tow reached the mooring cells, the set toward the right descending bank line was noticed but was not difficult to overcome. The stern had to be steered into the current to keep the stern from being driven into the right descending bank line. As the head of the tow almost reached the end of the guide wall, the current effect was almost totally gone. The stern tended to be pushed away from the guide wall by the eddy in the lock approach. An angle to the lock had to be maintained to keep the head on the guide wall until the head of the tow was inside the bullnose separating the two locks.

370,000 cfs - Coming from the end of the model to upstream of the I-24 bridge was not difficult (Plate 32). It was not difficult to work the tow over toward the right descending bank line to make the approach toward the lock. At a point slightly less than two tow lengths from the downstreammost mooring cell, the tow could be turned slightly to the left and the head of the tow would come landward of the mooring cells with little difficulty. As the tow reached approximately one tow length from the guide wall, the set toward the right descending bank line was slightly noticeable but was not difficult to overcome. Some small amount of left rudder had to be applied to keep the stern from being pushed toward the right descending bank line. As with the 300,000-cfs flow, the stern

was pushed away from the guide wall by the eddy in the lock approach and an angle had to be maintained to keep the head of the tow on the guide wall.

Although the eddy in the lower lock approach had a positive aspect in assisting the tow getting off the guide wall and turning out into the channel, this was more than offset by the tendency for the stern of the tow to be pushed off the guide wall on upbound approaches, especially in the higher discharge flow conditions.

Plan B-1

Description

In an effort to reduce the size and strength of the eddy that forms in the downstream lock approach between the downstream end of the powerhouse island and the right descending bank line, the use of training works on the west side of the powerhouse island was examined. Preliminary experiments were performed by placing materials in the model to form temporary training works. The changes to current patterns were observed by injecting dye or placing confetti in the model. From the observations of the changes in current patterns, the position, length, elevation, and spacing of structures was adjusted until the current patterns indicated improved conditions. These conditions were then examined by operating the model tow to verify these improvements. Also, as part of the final project, a series of fishing jetties were proposed to be installed on the left descending bank line to provide additional habitat for fish and areas to be used by recreational fishermen. Their impact on navigation conditions, if any, was also examined. The training work developed initially by this process and the installation of the proposed fishing jetties was designated as Plan B-1 (Figure 11).

Plan B-1 contains all the features of Plan B and the following additional features as shown in Figures 11 and 12:

a. A single spur dike, on the west bank of powerhouse island, 100 ft downstream of and parallel to the railroad bridge center line, with the root end at el 330.0 extending 35 ft channelward, then a 1 on 3 slope to the toe at el 290.0, an overall length of 155 ft.

b. Three fishing jetties, each approximately 70-ft long, spaced approximately 125 ft apart, with a crest width of 10 ft at el 310.0, angled approximately perpendicular to the bank along the left descending bank line between the boat basin and the left bank mooring cells.

Results, navigation conditions

Current directions and velocities. Current directions and velocities are shown in Plates 33-38. For the 35,000-cfs flow conditions (Plate 33) the currents were generally aligned with the bank lines and a large, but slow eddy formed, similar to the one formed for Plan B, in the lock approach. The velocities about one tow length downstream of the end of the guide wall were generally from

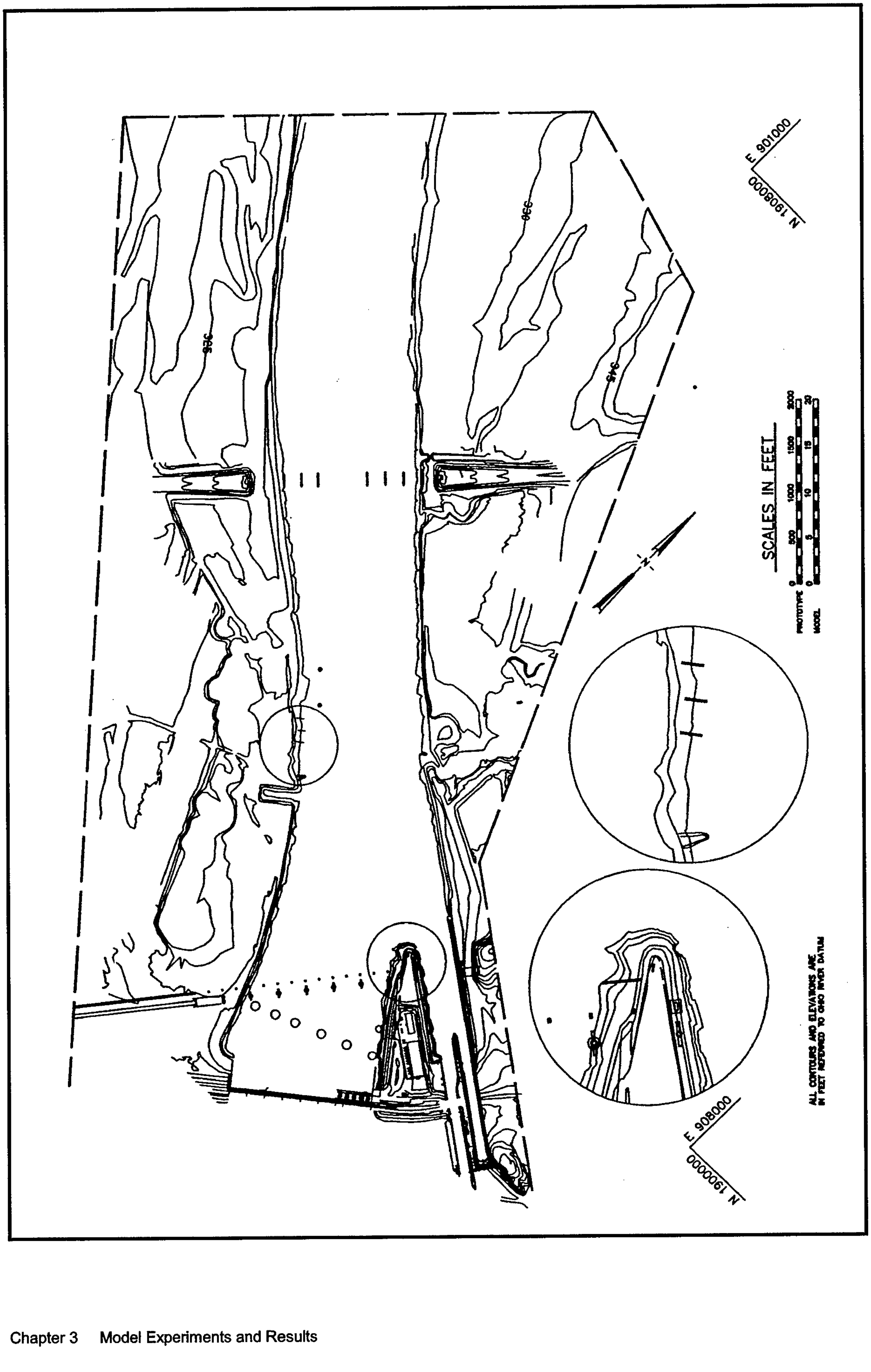


Figure 11. Plan B-1 conditions

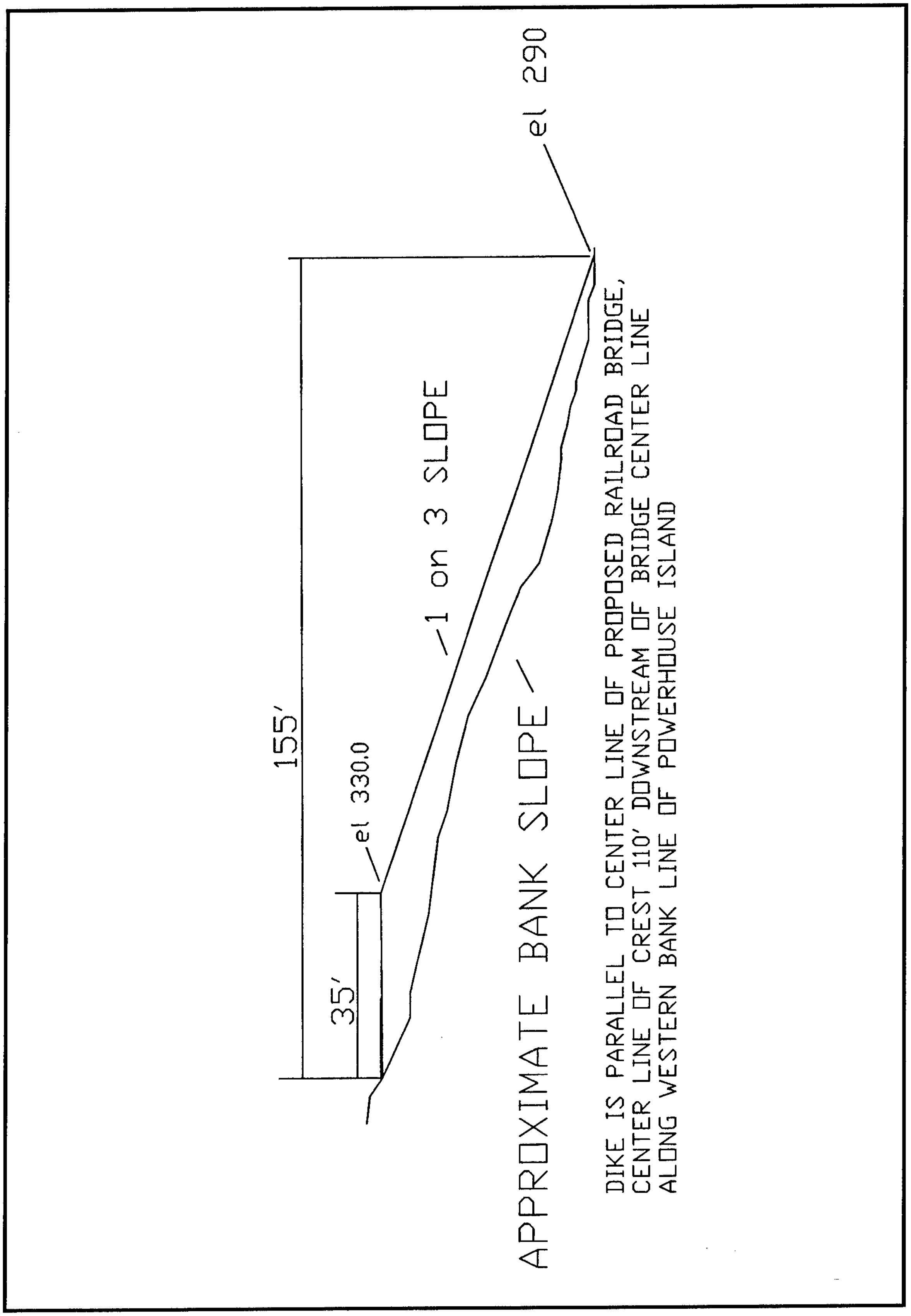


Figure 12. Plan B-1 dike

1.6 to about 2.6 fps. With the 79,000-cfs flow (Plate 34) the currents were again generally parallel to the bank lines and the eddy in the lock approach was about the same size and slightly stronger than the eddy with Plan B. Velocities at one tow length from the end of the guide wall were from about 2.9 to 5.3 fps. For the 100,000-cfs flow (Plate 35) the currents were generally aligned with the bank lines and the eddy in the lock approach was somewhat smaller and had approximately the same maximum velocity of 0.9 fps as the same flow condition for Plan B. The velocities at one tow length from the end of the guide wall were from 3.7 to 6.2 fps. For the 155,000-cfs flow (Plate 36) the currents were generally aligned with the bank lines and the eddy in the lock approach remained about the same size as Plan B but increased to a maximum of 1.8 fps as compared 1.4 fps in Plan B. The velocities at one tow length downstream of the end of the guide wall were from 3.5 to 5.6 fps. For the 300,000-cfs flow (Plate 37) the currents were again parallel to the bank lines and the angle that the currents were moving across the lower lock approach was slightly less than with Plan B. The size of the eddy was roughly the same as with Plan B, but the eddy moved approximately 100 ft downstream. The maximum velocity of the eddy moving upstream along the bank line was 1.5 fps, but the velocity crossing from the right bank toward the powerhouse island was only 0.4 fps as compared with 0.7 fps with Plan B. The velocities at one tow length downstream of the end of the guide wall were from 4.1 to 5.7 fps. For the 370,000-cfs flow (Plate 38) the flow moved out onto the overbanks but generally tended to follow the bank lines. The angle that the currents moved across the lock approach was approximately the same as with the 300,000-cfs flow condition. The eddy was still approximately the same size as Plan B, but was about 100 ft further downstream than with Plan B and was slightly slower with a maximum velocity at 1.1 fps. The velocities at one tow length from the end of the guide wall ranged from 2.1 to 5.3 fps.

Tow tracks, downbound. 35,000 cfs – There was no difficulty in getting the tow off the guide wall (Plate 39). There was some current set when the head of the tow was about one and one-half tow lengths downstream of the end of the guide wall. There was no significant difficulty in getting the head of tow out into channel, through the navigation span, and downstream to the end of the model.

79,000 cfs – There was no difficulty in getting the tow out of the lock, alongside the guide wall, and turning the tow to go out into the channel (Plate 40). The eddy and flow moving upstream along the right bank near the end of the guide wall helped the head of the tow to separate from the wall with only a slight use of rudder and engine of the tow required to turn out. Once sufficient angle on the tow in relation to the guide wall was attained, the tow could be brought ahead and could be started out into the channel. Some slight set was noted starting about one tow length downstream of the end of the guide wall, but nothing difficult to compensate for. The remainder of the transit through the navigation span to the end of the model was not difficult.

100,000 cfs - The eddy that was present in the lock approaches did little to help get the head of the tow off the guide wall (Plate 41). The head of the tow did not rotate toward the channel sufficiently until it was 200-300 ft downstream of the end of the guide wall, and it required more torquing to rotate the tow than with the lower discharge flows. The set of the current was noted as the head of the tow reached about one tow length downstream of the end of the guide wall

and was not diminished until the head was slightly over two tow lengths downstream of the guide wall. The tow was not overly difficult to maneuver out into the channel and through the navigation span.

300,000 cfs – Flow moving upstream along the face of the guide wall started trying to separate the tow from the guide wall before the tow could clear the lock chamber (Plate 42). Once the tow was clear of the chamber, the head rotated out on its own. The strong set toward the right descending bank line started when the head was slightly less that one tow length from the end of the guide wall. This strong set finally diminished when the head was about three tow lengths downstream of the guide wall. After this point, the tow could be aligned to go through the navigation span, getting fully aligned less than a full tow length upstream of the I-24 bridge. The maneuvering required was not overly difficult for this flow condition and was approximately the same as noted for Plan B.

370,000 cfs – The tow moved easily out of the lock and along the guide wall (Plate 43). The eddy near the downstream end of the guide wall helped the head of the tow rotate channelward. As the stern of the tow cleared the end of the guide wall, the tow was turned hard left to go out into the channel. The current set was felt starting when the head of the tow was about one tow length downstream of the end of the guide wall and was almost fully diminished when the tow reached two tow lengths downstream of the guide wall. It was not difficult to steer the tow out into the channel and through the navigation span.

Tow tracks, upbound. 35,000 cfs – There was no difficulty in coming from the end of the model to well upstream of the bridge (Plate 44). The approach to the lock was almost straight in with almost no current set. Getting the tow onto the guide wall and into the lock was not difficult.

79,000 cfs – Navigation conditions (Plate 45) were similar to those with the 35,000-cfs flow (Plate 44). The approach was almost straight with almost no noticeable current set and no difficulty in getting to the guide wall and into the lock.

100,000 cfs – The upbound approach (Plate 46) could be made in almost the same manner as with the 35,000- and 79,000-cfs flow conditions (Plates 44 and 45). The tow could be driven almost directly into the lock approach with only a slight current set starting about two tow lengths downstream of the end of the guide wall. There was no difficulty in getting the tow on the guide wall and into the lock.

300,000 cfs – Coming from the end of the model up to the highway bridge was not difficult (Plate 47). Once the tow was upstream of the bridge, it wasn't difficult to work the tow over to the right descending bank. Current set toward the right bank was apparent starting about three tow lengths downstream of the end of the guide wall, but was not difficult to overcome. Approaching the guide wall and getting the head on the wall was not difficult. There was still some tendency for the eddy in the lock approach to rotate the stern away from the guide wall and keep the head of the tow off the wall. This tendency was less than was noted with the Plan B condition, but was still stronger than desirable.

370,000 cfs - Coming from the end of the model to past the bridge was not difficult (Plate 48). The tow was driven more or less directly into the current until the head was about one tow length downstream of the end of the guide wall. At that point the tow could be turned slightly left and the current set would finish turning the tow and setting it toward the right descending bank line. Controlling the amount of movement of the tow in this current set was not difficult. Getting onto the guide wall and into the lock was not difficult.

The fishing jetties installed on the left descending bank had no appreciable effects on navigation either upbound or downbound with any flow condition examined.

During meetings with towing industry representatives in April 2000, the results of Plan B-1 were presented and demonstrations were performed on the model. The general consensus of the towing industry was that the eddy that formed in the downstream lock approach should further be reduced in strength and size and be pushed as far downstream from the end of the guide wall as possible. All of the towing representatives agreed that navigation conditions downbound, as presented in the model, would not be a problem and getting the tow off the guide wall and angled sufficiently to get through the current set and out into the channel would not present a problem. They viewed the potential problems that upbound tows would have getting the tow onto the guide wall and keeping it there with the eddies in the size, strength, and position as indicated by the model, especially at the 300,000-cfs flow condition, would be the greater navigation problem.

Plan B-2

Description

To further improve navigation conditions in the lower lock approach, a preliminary design using two training dikes located along the western side of the powerhouse island was developed.

After development of a preliminary design and prior to documentation with this design, ERDC was requested to install a proposed design for fishing piers to be placed on the west side of the powerhouse island and the west bank downstream of the spillway (Figures 13 and 14). These piers were elevated with the 10-ft-wide walkway being built on a 4-ft square box beam supported on concrete pilings. The piers were to be placed immediately upstream of the proposed highway bridge and the channelward ends of the piers were to be directly underneath the bridge.

The design elevation of these piers was such that portions of the roadway and box beam, starting at the channelward end, would be in the water or submerged during periods of time when the tailwater reached or exceeded approximately 313.0. During these periods of time, the fishing piers would cause flow to be diverted around and over them and would in effect become a form of training work. The design for training dikes was re-evaluated to determine if a single training dike, working with the fishing jetties could be as effective as the

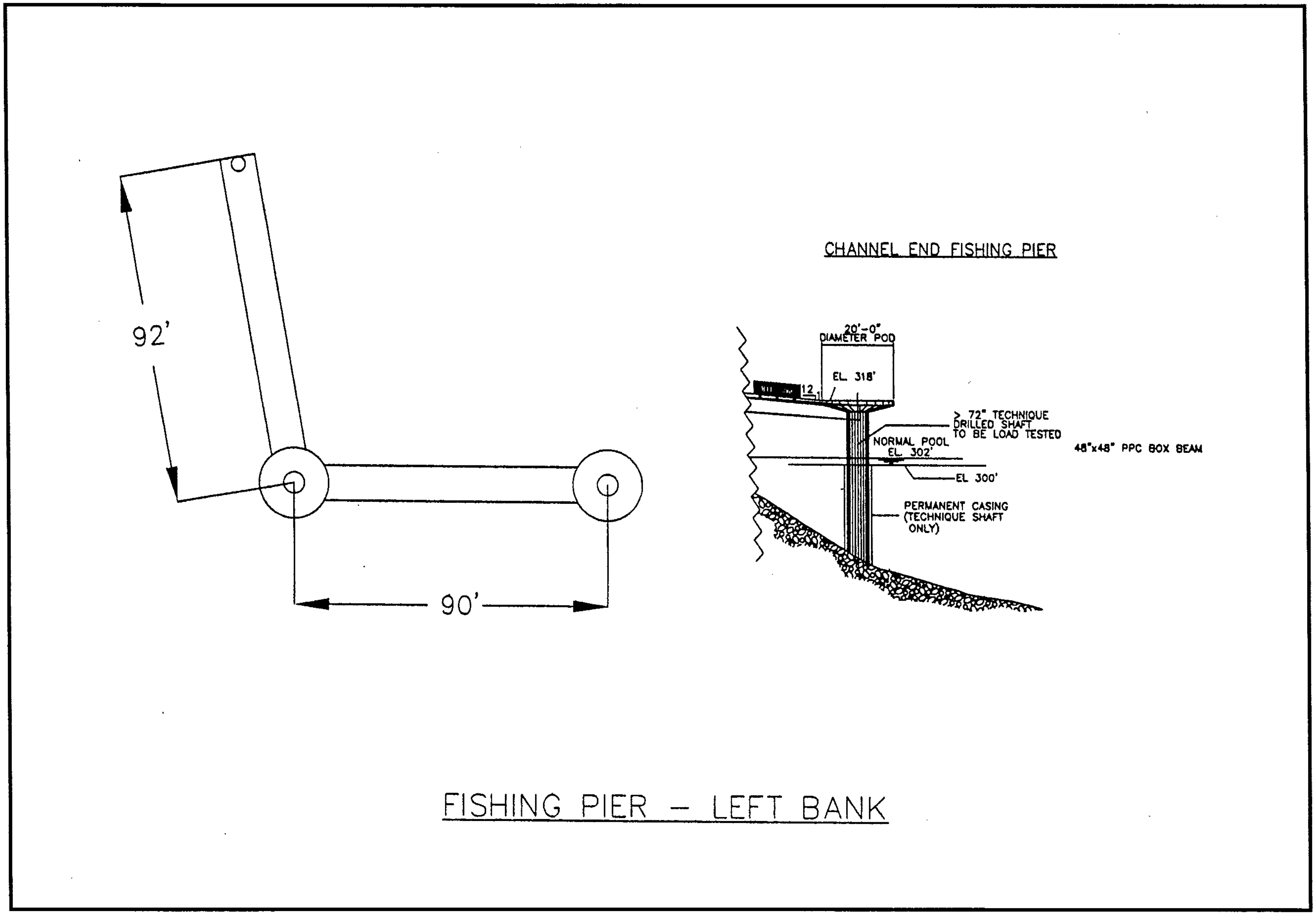


Figure 13. Left bank fishing pier

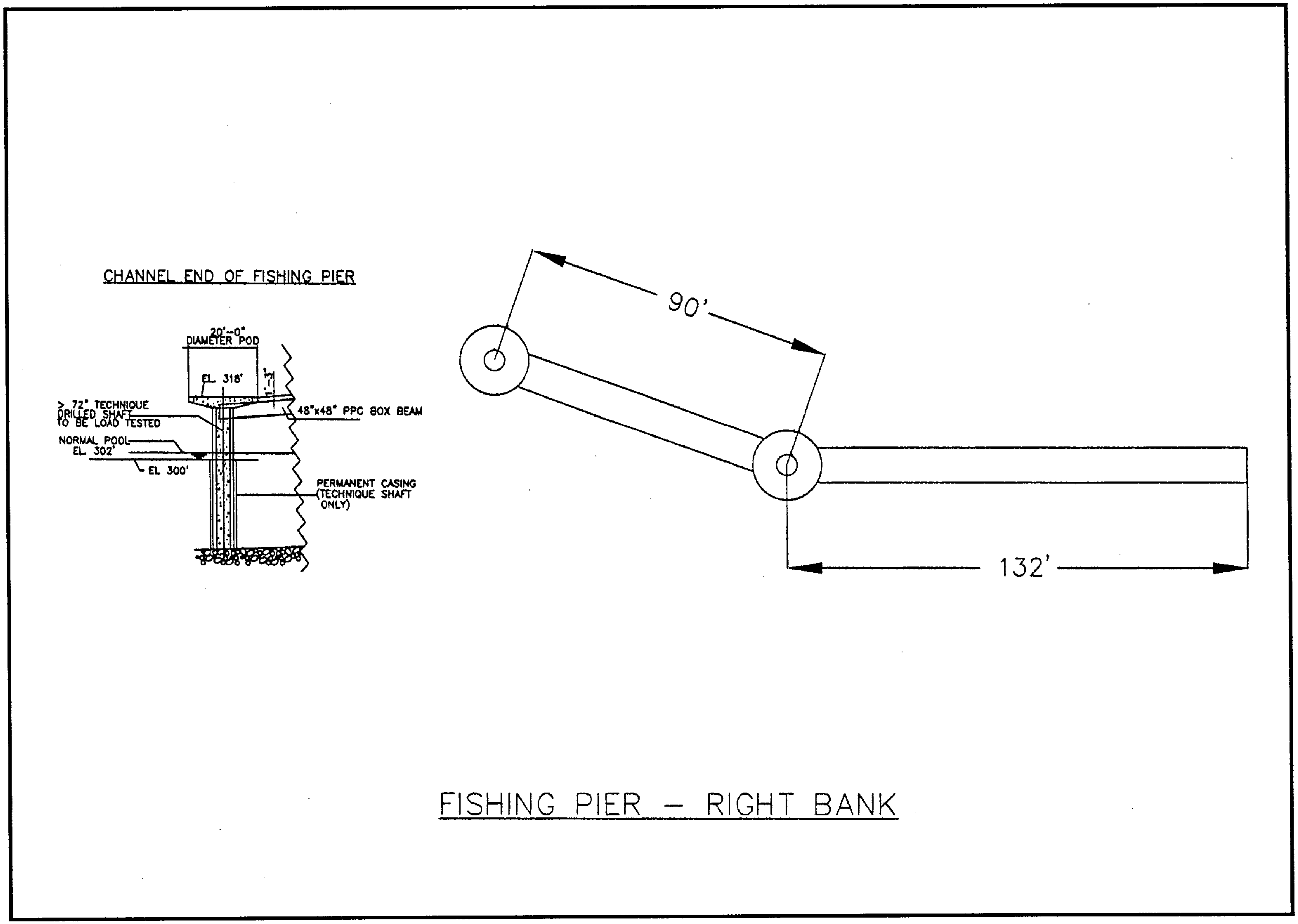


Figure 14. Right bank fishing pier

preliminary two-dike plan. The plan developed for a single training dike to be used in conjunction with the fishing jetties was designated Plan B-2 (Figure 15).

Plan B-2 contains all the features of Plan B and the following additional features as shown in Figures 15 and 16:

a. The fishing piers on the left and right banks underneath the proposed highway bridge.

b. A training dike with the root end approximately 230 ft downstream of the center line of the proposed railroad bridge, approximately 188 ft overall length, and angled approximately 48 deg downstream of the center line of the proposed railroad bridge (Figure 16).

c. Three fishing jetties, each approximately 70 ft long, spaced approximately 125 ft apart, with a crest width of 10 ft at el 310.0, angled approximately perpendicular to the bank along the left descending bank line between the boat basin and the left bank mooring cells (same as those used for Plan B-1).

Results, navigation conditions

Current directions and velocities. Current directions and velocities are shown in Plates 49-54. For the 35,000-cfs flow conditions (Plate 49) the currents were generally aligned with the bank lines and a large, but slow eddy formed, similar to the one formed for Plan B and B-1, in the lock approach. The velocities about one tow length downstream of the end of the guide wall were generally from 2.1 to about 3.1 fps. With the 79,000-cfs flow (Plate 50) the currents were again generally parallel to the bank lines and the eddy in the lock approach was about the same size and slightly stronger than the eddy with the 35,000-cfs flow condition. Velocities at one tow length from the end of the guide wall were from about 4.0 to 6.3 fps. For the 100,000-cfs flow (Plate 51) the currents were generally aligned with the bank lines and the eddy in the lock approach was smaller and had less velocity (0.6 fps) as that with the 79,000-cfs flow (Plate 50). The velocities at one tow length from the end of the guide wall were from 3.9 to 6.5 fps. For the 155,000-cfs flow (Plate 52) the currents were generally aligned with the bank lines and the eddy in the lock approach had remained about the same size but had increased to a maximum of 1.8 fps as compared to the 100,000-cfs flow (Plate 51). The velocities at one tow length downstream of the end of the guide wall were from 3.8 to 5.8 fps. For the 300,000-cfs flow (Plate 53) the currents were again parallel to the bank lines and the angle that the currents were moving across the lower lock approach was slightly less than with Plan B-1. The size of the eddy was slightly smaller and was approximately 100 ft further downstream than with Plan B-1, and the maximum velocity was reduced to 0.8 fps. The velocities at one tow length downstream of the end of the guide wall were from 4.8 to 6.4 fps. For the 370,000-cfs flow (Plate 54) the flow moved out onto the overbanks but generally tended to follow the bank lines. The angle that the currents moved across the lock approach was approximately the same as with the 300,000-cfs flow condition. The eddy in the lock approach had moved approximately 400 ft downstream, had elongated somewhat, and was slower that with the 300,000-cfs condition with a maximum velocity of 0.5 fps.

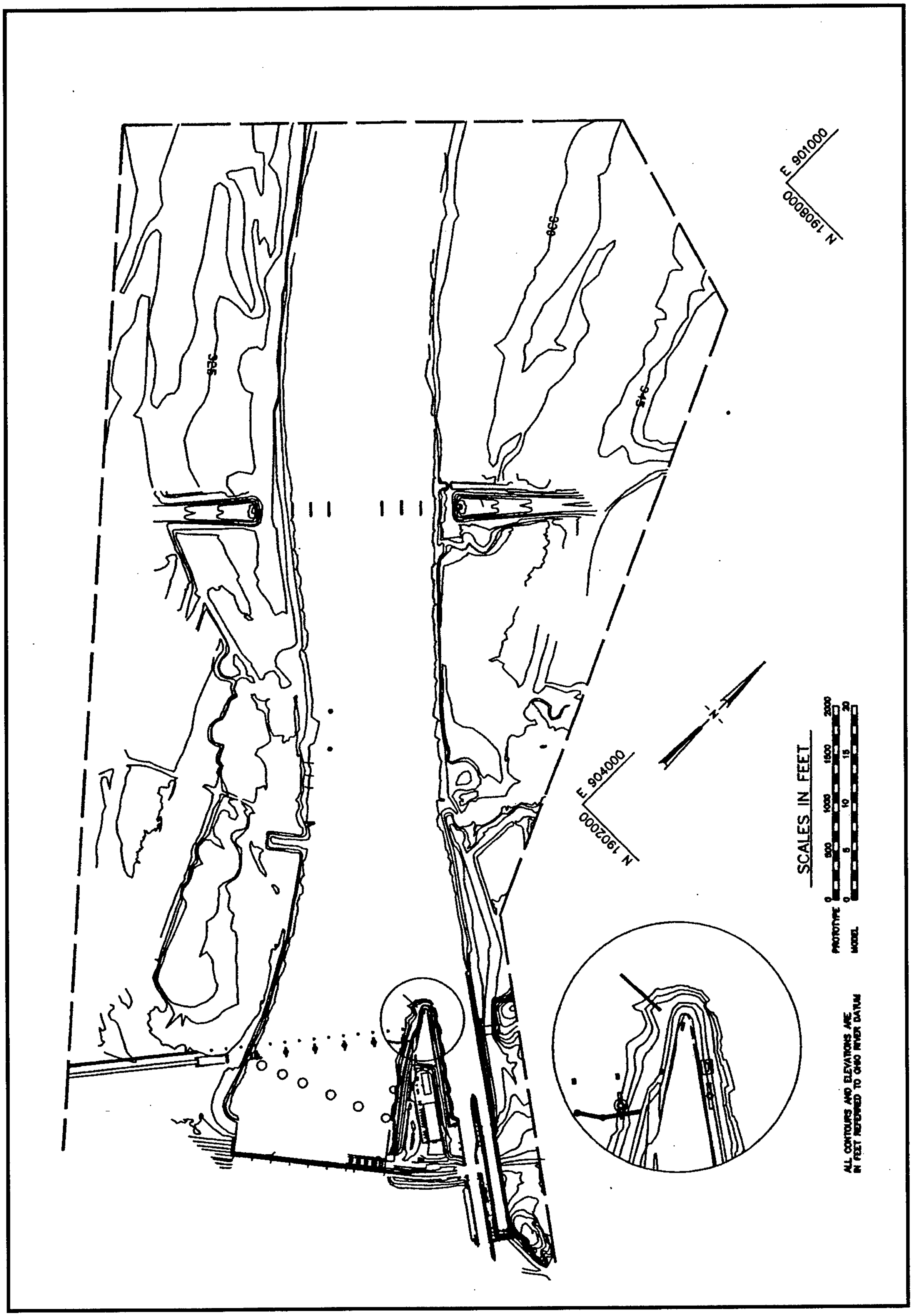


Figure 15. Plan B-2 conditions

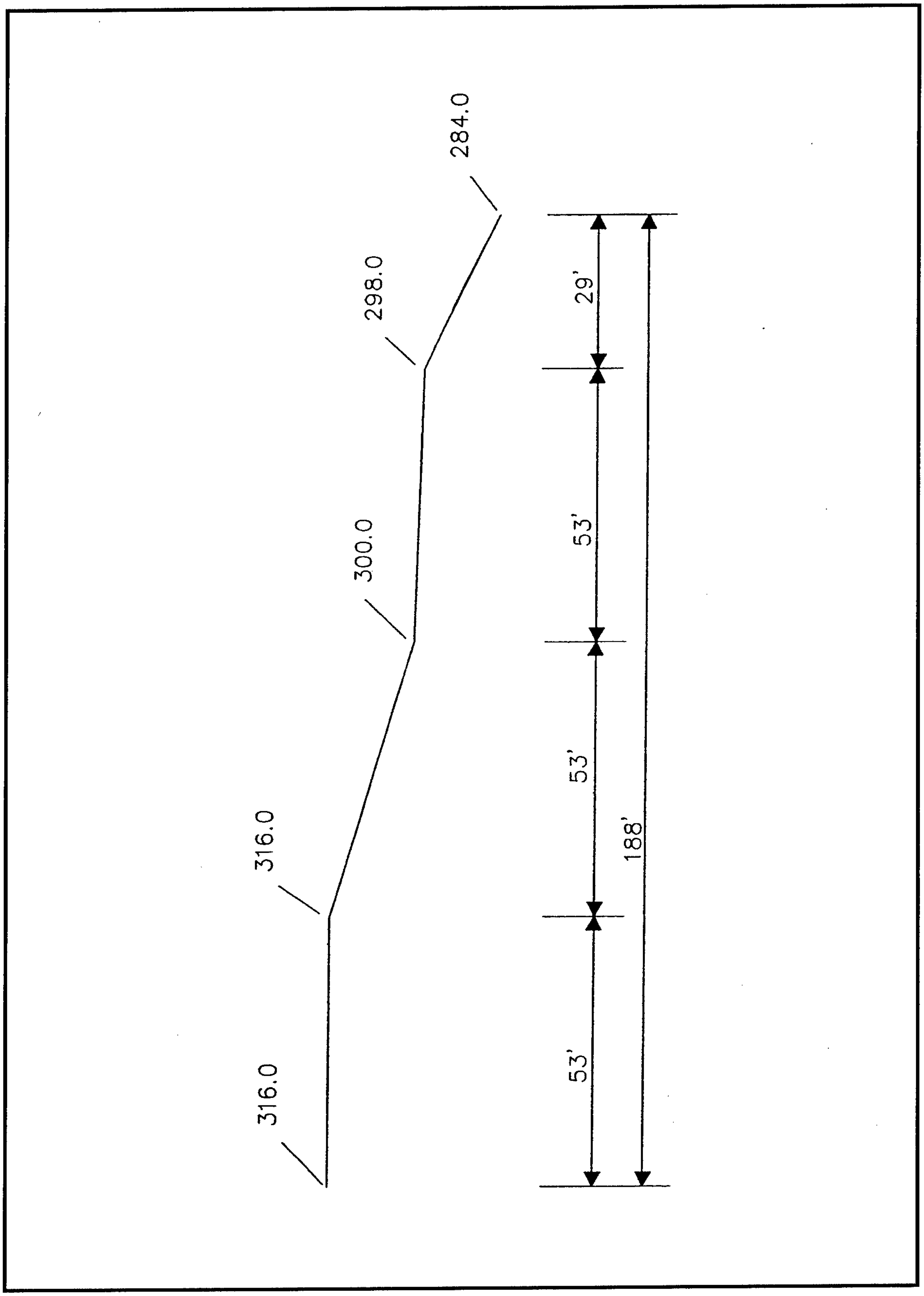


Figure 16. Plan B-2 dike

The velocities at one tow length from the end of the guide wall ranged from 3.5 to 5.4 fps.

Tow tracks, downbound. The training work, fishing jetties, and fishing piers installed for Plan B-2 were considered to be the postproject conditions. To establish what the postproject navigation conditions would be, evaluations of navigation conditions, using the model tow and push boat, were made for both the old 600-ft lock and the new 1,200-ft lock.

During evaluation of the base conditions (preproject), the 155,000-cfs flow condition was used for documentation of flow recirculation below the spillway and was not evaluated for navigation conditions. Since this flow condition was still being used to monitor changes in the recirculation patterns that might be caused by the installation of the proposed training structures, fishing piers, highway and railroad bridge piers, it was considered prudent to evaluate this flow for any potential navigation problems that might occur at this particular discharge and tailwater condition with Plan B-2.

35,000 cfs, new lock - There was little difficulty in turning the head of the tow away from the guide wall (Plate 55). The tow could be rotated off the wall by using right engine and hard left rudder. The tow did not rotate well until the head passed the end of the guide wall, then it started rotating faster. As the tow came off the wall and out into the channel there was not as much current set as noted with the base conditions, Plan B, and Plan B-1. Almost no left rudder was needed to get the tow out into the channel. The tow could be steered right to come into alignment with the navigation pass by the time the head of the tow reached opposite the most upstream of the two left bank mooring cells. There were no difficulties going through the navigation span and downstream to the end of the model.

35,000 cfs, old lock - The tow was eased slowly out of the lock and along the guide wall (Plate 56). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid grounding, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

79,000 cfs, new lock – There was no problem getting out of lock and alongside the guide wall (Plate 57). As the stern of the tow cleared the lock, the rudder was turned hard right, the left engine stopped, and the right engine put slow ahead. The tow torqued off the wall on the starboard quarter, rotating the head away from the guide wall. When sufficient angle was achieved, the left engine was brought ahead and the rudders set to midships. The tow moved out easily into the channel and required only a slight turn to the left to overcome the current set. The tow could be steered right once the head of the tow reached the more upstream of the two left bank mooring cells.

79,000 cfs, old lock – The tow was eased slowly out of the lock and along the guide wall (Plate 58). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid ground, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

100,000 cfs, new lock - The tow was torqued as with the 35,000-cfs and 79,000-cfs flow conditions and rotated easily away from the wall (Plate 59). Steering out into the channel and through the navigation span was similar to that with the 79,000-cfs flow.

100,000 cfs, old lock - The downbound conditions (Plate 60) from the existing lock were similar to those with the 35,000- and 79,000-cfs flow conditions (Plates 56 and 58).

155,000 cfs, new lock – The tow was brought out of the lock and rotated similar to that with the lower discharge flows (Plate 61). There appeared to be slightly more help from the current to rotate the tow away from the wall. Leaving the guide wall and coming out into the channel required the tow to be steered to the left, but not with full left rudder and not for an extended period. Turning into the alignment for the navigation span was not difficult.

155,000 cfs, old lock - The downbound conditions (Plate 62) from the existing lock were similar to those with the 35,000-, 79,000-, and 100,000-cfs flow conditions (Plates 56, 58, and 60).

300,000 cfs, new lock – The tow was brought out and maneuvered the same as with the lower discharge flows (Plate 63). As with the 155,000-cfs, there seemed to be some slight assist from the eddy in the lock approach, but not nearly as much as noted in Plan B or B-1. Steering the tow out into the current did not seem as difficult as with either Plan B or B-1. There was no difficulty in passage through the bridge and downstream to the end of the model.

300,000 cfs, old lock – The tow was slowly moved out of the lock and along the guide wall (Plate 64). As the stern cleared the lock, the tow was turned left. Once the tow had sufficient angle to go out into the current, usually when the stern was about halfway down the proposed guide wall, the engines were brought up to the permissible power settings and the tow steered out into the current. The current set seemed stronger from the tow coming out of the old lock as opposed to the tow coming out of the new lock with this same flow condition. The tow was maneuvered out into the channel and could be aligned to go through the navigation span with moderate difficulty. Although this condition was more difficult than navigating out of the new lock, it was less difficult than with the existing conditions.

370,000 cfs, new lock - Getting off the guide wall and out along the powerhouse island was not difficult (Plate 65). As noted with the other flows, the head of the tow must be rotated by using the right engine and hard left rudder. The head rotated off the wall, but not very fast until the head passed the downstream end of the guide wall. There, the rotation of the head away from the right bank accelerated. Once sufficient angle into the current was achieved, the engines were both brought ahead and the rudder set to midships. The crosscurrent that was noted during the existing conditions, Plan B and B-1, was not as strong with Plan B-2. The tow only required steering slightly left to resist the slide and quickly came out into the channel. By the time the head of the tow was approaching the left bank mooring cells, the tow could be steered right and into alignment with the bridge.

370,000 cfs, old lock – The tow was moved slowly out of the lock along the left side guide wall (Plate 66). As the stern of the tow cleared the divider between the locks, the tow was steered left, causing the head of the tow to turn out into the channel just downstream of the end of the island. It was easy to get a good angle to go out into the current. The tow easily moved out into the current, out into the channel, and was turned to go through the navigation span with little difficulty.

Tow tracks, upbound. 35,000 cfs, new lock – There was no difficulty in coming from the end of the model to well upstream of the I-24 bridge (Plate 67). The approach could be made slightly more direct than with higher discharge flows. The tow was allowed to start sliding toward the right descending bank line after passing the upstreammost of the left bank mooring cells. The tow slid across the lock approach and the head made contact with the guide wall about midlength of the wall. There was no difficulty in keeping the head on the wall and moving upstream along the wall and into the lock.

35,000 cfs, old lock - The tow was maneuvered through the bridge and past the left bank mooring cells (Plate 68). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. The amount of the slide could be controlled with right rudder. As the tow got into the almost slack water of the lock approach the head stopped sliding and the engines had to be slowed to reduce speed. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

79,000 cfs, new lock – Navigation conditions (Plate 69) were similar to those with the 35,000-flow (Plate 67). The tow was steered slightly toward the left descending bank after passing through the bridge then more or less straight upstream until the head of the tow was about one tow length from the end cell of the guide wall. At this point, the tow could be steered slightly left and the current would cause the tow to slide across the channel toward the lock approach. Some right rudder was used to help control the rate of the slide. The tow slid across the approach and the head of the tow did not get near the guide wall until it was midlength of the wall. It was easy to keep the head of the wall and let the stern continue to slide down until the tow was completely on the wall. This occurred

when the head was about 200-300 ft from the bullnose separating the two locks. Entry into the lock was not difficult.

79,000 cfs, old lock - The tow was maneuvered through the bridge and past the left bank mooring cells (Plate 70). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. The slide could be controlled with the application of right rudder. As the tow got into the slack water of the lock approach, the head stopped sliding and the engines had to be slowed to keep the tow from accelerating. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

100,000 cfs, new lock – Navigation from the end of the model to well upstream of the bridge was not difficult (Plate 71). The approach that appeared to work best was to steer similar to that with the 79,000-cfs flow (Plate 69). The slide across the channel was not difficult and the landing on the guide wall was similar to that with the 79,000-cfs flow.

100,000 cfs, old lock – Navigation conditions (Plate 72) were similar to those with the 79,000-cfs flow (Plate 70).

155,000 cfs, new lock – The upstream passage was performed in approximately the same manner as the lower discharge flows (Plate 73). The current was stronger so the slide from the left bank had to be controlled by more right rudder, but not anything that might be considered excessive. The head of the tow tended to reach the guide wall at approximately two-thirds of its length from the lock. It was not difficult to keep the head of the tow on the guide wall and get the stern on the wall.

155,000 cfs, old lock - The tow was maneuvered through the bridge and past the left bank mooring cells (Plate 74). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. The amount of slide could be controlled with the right rudder. As the tow got into the slack water of the lock approach, the head stopped sliding. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock. These conditions were similar to those with the 79,000- and 100,000-cfs flows.

300,000 cfs, new lock – The tow maneuvered in a similar manner as with the lower discharge flows (Plate 75). When the head of the tow was approximately one tow length from the end of the guide wall, the tow was steered slightly left. The tow immediately started sliding toward the right bank, but the slide was easily controlled with application of right rudder. The tow tended to slide across the approach and the head got near the guide wall when it was about 100 to 200 ft from the downstream end. The head was easy to keep on the guide wall, and the stern could be maneuvered over to the guide wall with minimal difficulty.

300,000 cfs, old lock – The tow was maneuvered upstream through the I-24 bridge and past the mooring piers as normal (Plate 76). Once the tow was from 1 to 1.5 tow lengths from the end of the island, the tow was steered slightly left and the current slid the tow toward the right bank. Controlling the slide with the right rudder was not difficult. As the head of the tow reached the end of the island, the tow was aligned with the guide wall. The tow was driven slowly and maneuvered to keep the head near the island. As the head got to within about 400-500 ft of the end of the guide wall, the engines were reversed to slow the tow. The tow was flanked to the right to keep the stern near the bank and help get the head of the tow inside the alignment of the guide wall. Once the head was on the guide wall, the engines were brought forward slowly and the tow moved along the guide wall and into the lock. There was no serious threat to the bridge piers along the eastern edge of powerhouse island as long as the tow remained in powered control.

370,000 cfs, new lock – As with the 300,000-cfs flow condition, the tow was brought through the bridge and up near the left bank mooring cells (Plate 77). As the head of the tow reached approximately one tow length from the downstream end of the guide wall, the tow was steered slightly left and the current caused the tow to slide toward the right bank. The slide was easily controlled with the right rudder. The head of the tow reached the guide wall about midlength of the wall. There was no difficulty in keeping the head on the wall and getting the stern on the wall.

370,000 cfs, old lock – The tow was driven upstream through the I-24 bridge and past the mooring cells as was normally done (Plate 78). Once the tow was about 1 to 1.5 tow lengths from the end of the island, the tow can be steered slightly left and the current would cause the tow to slide left. It was easy to control the amount of slide by applying right rudder. As the tow got into alignment with the lock with the head just downstream of the end of the island, the slide on the head of the tow was diminished and engine power had to be reduced to control the speed. The tow was maneuvered to keep the head aligned with the guide wall. The flow over the end of the island tended to cause the stern of the tow to slowly be pushed toward the right bank. This was not difficult to control. As the head of the tow reached the downstream end of the guide wall, the tow was angled slightly toward the guide wall to keep the head of the wall. As the head moved down the wall, the stern could be steered toward the island. The tow was aligned to enter the lock by the time the head reached the lock opening. There was no tendency for the tow to threaten the bridge piers while in powered control.

Plan C – Spillway Training Works

Description

After completion of design and evaluation of training works to improve navigation in the lower lock approach with the proposed 1,200-ft lock (Plan B-2), the model was used to develop training works in the spillway below the dam (Plan C). These training works were developed to reduce the size and strength of an eddy that forms downstream of the spillway at a 100,000-cfs flow condition (Plate 3) and also to improve flow mixing from the spillway and the powerhouse

tailrace. The objective to reducing the size and strength of this eddy was to enhance safety for recreational boaters who extensively use this area. An additional benefit of reducing the eddy size and strength would be to decrease the gas saturation levels that were presently experienced at this flow condition and possible improvement of mixing characteristics of the tailrace and spillway flow. KDWFR representatives established the 100,000-cfs flow condition as being the most critical in reducing the eddy size and strength. This flow condition has maximum powerhouse flow and the three spillway gates adjacent to the powerhouse open. When there were more spillway gates opened, recreational boaters remain well away from the spillway. When there were three gates or less open, boaters were restricted to stay only a few hundred feet from the spillway. The eddy that forms with the 100,000-cfs flow condition without any training works extends downstream from the spillway considerably farther than this and produces flow moving upstream along the left descending bank and across the spillway toward the open spillway gates. There have been reported cases of boaters drifting in this eddy and being pulled back into the spillway.

At the beginning of the model studies, a flow of 155,000-cfs was established to be a condition associated with high fish mortality. It was later determined by KDWFR that recreation boaters were restricted from the area immediately downstream of the spillway when more than three gates were open on the dam so boater safety was not as great an issue as with a flow of 100,000-cfs with three gates open. It was also observed that the dam operates with three gates or less open for the majority of a typical year. KDWFR determined that it was more expedient to design for an event that occurs more frequently and where there was likely to be more problems with boater safety.

To develop the training works in the spillway for Plan C, the model was left in the Plan B-2 configuration (powerhouse island training work to improve navigation conditions in the lower lock approach) and the 100,000-cfs flow condition was set. Temporary training structures (in this case, bricks) were placed and evaluated for their effectiveness in reducing the size and strength of the eddy. For visualization, dye and confetti were placed in the model and observed to determine how various placements of these temporary training works influenced the size and strength of the eddy. The height of the training works was set not to exceed the height of the old railroad piers, el 295.0. The position, length, angle to flow, and number of structures was varied until a combination was achieved which provided the most reduction to the size and strength of the spillway eddy for the 100,000-cfs flow condition. The temporary training works were removed and typical side sloped dike structures were fabricated using the position, length, elevation, and angle derived from the temporary structures. The model was again set up with the 100,000-cfs flow conditions and the eddy visualized with dye and confetti. Adjustments were made to the position and angle of the side sloped training works until the model replicated the dye and confetti patterns noted with the temporary training works. The final positions, lengths, elevations, and cross sections of the spillway training works developed for Plan C were shown in Figures 17 and 18.

To evaluate how the installed spillway training works would affect the eddy in the spillway and navigation conditions in the lower lock approach, the model was operated with the same six flow conditions as used for previous testing.

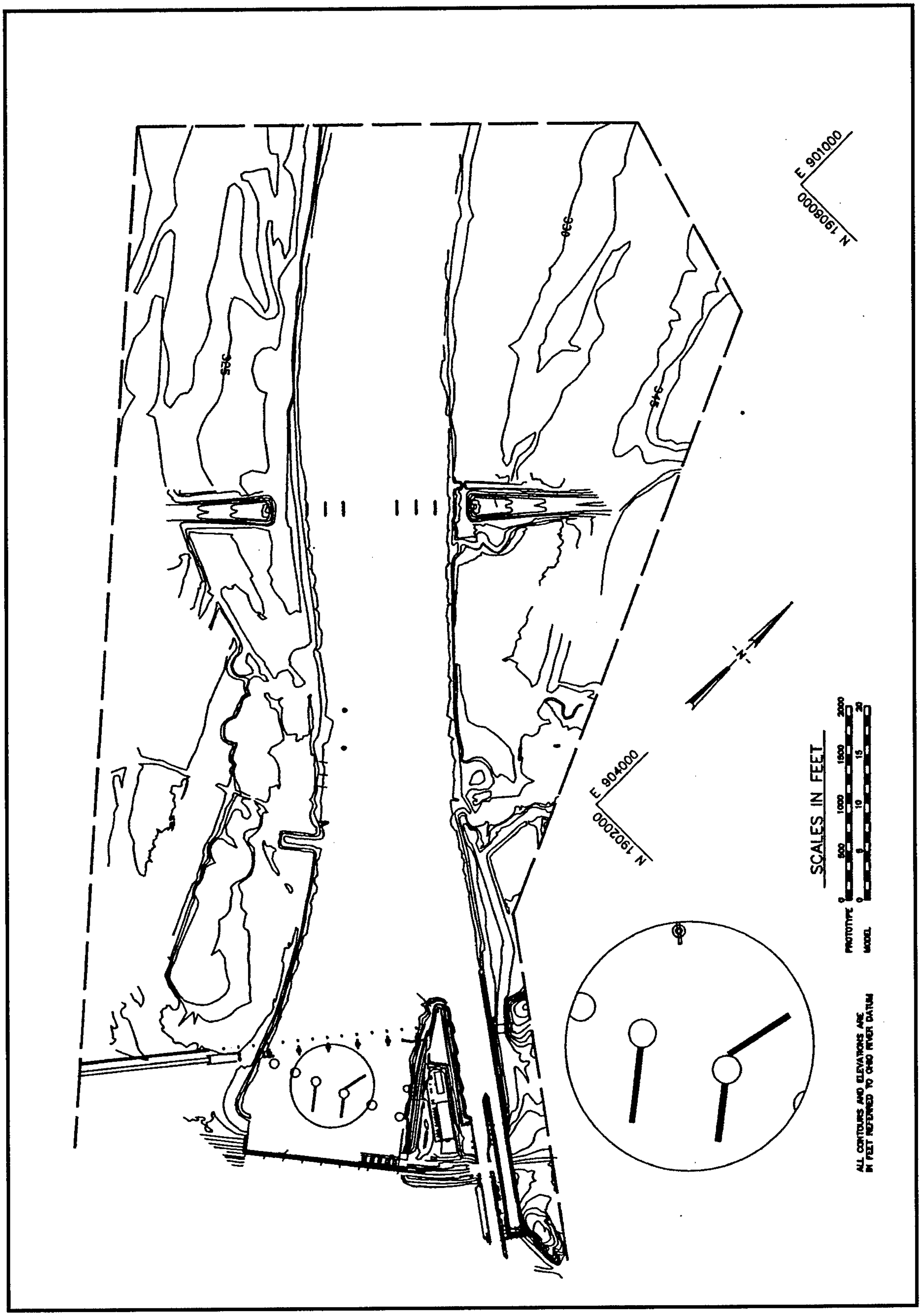


Figure 17. Plan C conditions

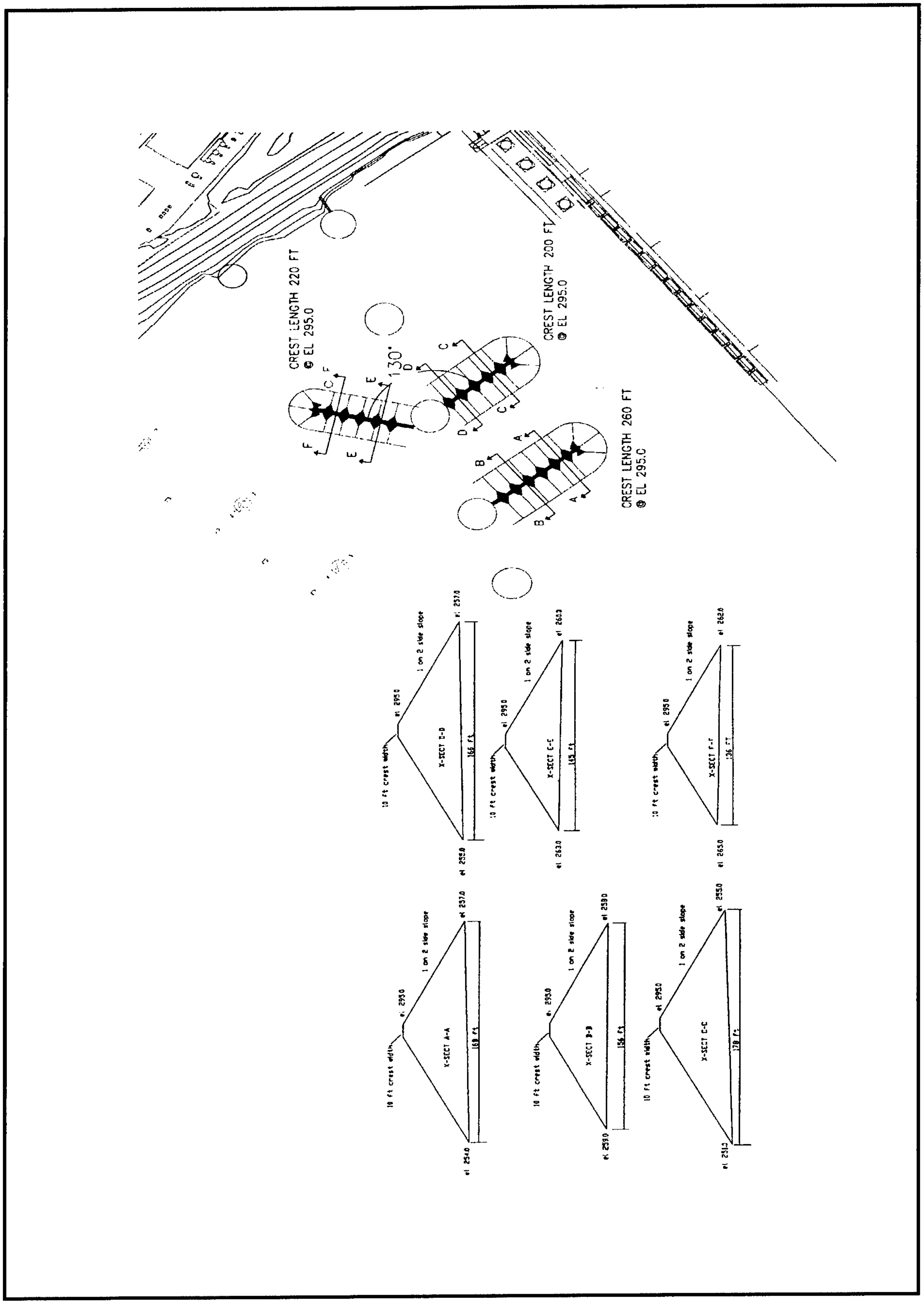


Figure 18. Plan C dikes

Current directions and velocities were collected and tow operations performed and recorded for each flow condition. Current directions and velocities and the tow tracks for Plan C were then compared to those collected for Plan B-2 to determine the effect of installation of the proposed spillway training works.

Plan C contains all the features of Plan B-2 and the following additional features as shown in Figures 17 and 18: Three submerged dikes downstream of the stilling basin, all with crest elevation of 295.0.

Results, navigation conditions

Current directions and velocities. 35,000 cfs – The eddy in the spillway for Plan C (Plate 79) was smaller, slower, and did not extend as far downstream as that of Plan B-2 (Plate 49). The velocities off the end of the powerhouse island training dike were slightly reduced with Plan C versus Plan B-2 and the eddy in the lower lock approach for Plan C was smaller and slightly slower than with Plan B-2. The velocities about one tow length downstream of the end of the guide wall varied from 1.9 to 3.2 fps.

79,000 cfs – The eddy in the spillway for Plan C (Plate 80) was somewhat smaller than that recorded with Plan B-2 (Plate 50). Instead of two large eddies in Plan B-2, there were three smaller eddies in Plan C. The largest eddy in Plan C did not extend upstream to the spillway as did the eddy in Plan B-2. The eddy velocities for Plan C were slightly reduced as compared to those of Plan B-2. The velocities off the end of the powerhouse island training dike were the same or slightly higher with Plan C versus Plan B-2, and the eddy formed in the lower lock approach was slightly larger for Plan C than for Plan B-2, but has approximately the same velocity. The velocities about one tow length downstream of the end of the guide wall varied from 5.5 to 6.7 fps.

100,000 cfs – The eddy in the spillway for Plan C (Plate 81) was confined to upstream of the proposed highway bridge as compared to extending downstream of the proposed railroad bridge by up to 300 ft for Plan B-2 (Plate 51). The velocity of the eddy for Plan C along the left bank just upstream of the proposed bridges was 1.3 fps as compared with 3.4 fps at the same position with Plan B-2. The velocity of the eddy crossing the spillway with Plan C was about 1.5 fps as compared with 2.7 fps near the same position with Plan B-2. A small counterclockwise eddy still existed downstream of the proposed bridges with Plan C, but it was confined to well downstream of the proposed bridges and was completely disconnected from the large upstream eddy. The velocities off the end of the powerhouse island training dike out into midchannel were higher for Plan C compared to Plan B-2. Along the left bank, from the proposed bridges down to near the proposed left bank fish jetties, the velocities were lower with Plan C as compared with Plan B-2. The velocities were approximately the same for both plans after passing the proposed left bank fishing jetties, which were approximately 4,000 ft downstream from the axis of the dam. The eddy in the downstream lock approach was larger and had a higher velocity for Plan C as compared with Plan B-2. This eddy was downstream of the lower end of the proposed guide wall. The velocities about one tow length downstream of the end of the guide wall varied from 5.7 to 6.7 fps.

155,000 cfs – The eddy in the spillway for Plan C (Plate 82) was only moderately different than that with Plan B-2 (Plate 52). The eddy in both plans were approximately the same size, but it appeared that the velocity of the eddy with Plan C may have been slightly less than with Plan B-2, especially near the left bank spillway abutment wall. The velocities off the end of the powerhouse island training dike were almost unchanged with Plan C versus Plan B-2 and distribution of the velocities across the channel were approximately the same for both plans. The eddy formed in the downstream lock approach was almost identical in size and velocity with Plan C as compared to Plan B-2. The velocities about one tow length downstream of the end of the guide wall varied from 5.0 to 5.9 fps.

300,000 cfs – Velocities along the left bank immediately upstream of the proposed bridges appeared to be higher for Plan C (Plate 83) as compared to Plan B-2 (Plate 53). The velocities were somewhat lower along the right bank for Plan C as compared to Plan B-2. Velocity distribution across the channel was approximately the same for both plans after passing the downstream end of the powerhouse island. Velocities off the end of the powerhouse island training dike were lower for Plan C versus Plan B-2. The eddy in the downstream lock approach was approximately the same location, size, and strength for Plan C as compared to Plan B-2. The velocities about one tow length downstream of the end of the guide wall varied from 4.4 to 6.0 fps.

370,000 cfs – The velocities in the spillway did not indicate any appreciable differences with Plan C (Plate 84) as compared with Plan B-2 (Plate 54). The velocities off the end of the powerhouse island training dike were somewhat higher with Plan C versus Plan B-2. The eddy in the downstream lock approach extended slightly less downstream and was slightly higher in velocity with Plan C as compared with Plan B-2. The velocities about one tow length downstream of the end of the guide wall varied from 4.1 to 4.6 fps.

Tow tracks, downbound. 35,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 85 and 55) indicated no change in navigation conditions between the two plans.

35,000 cfs, old lock - The tow was eased slowly out of the lock and along the guide wall (Plate 86). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid ground, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

79,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 87 and 57) indicated no significant differences between the two plans. The ability to turn the tow out into the channel immediately downstream of the powerhouse island did appear to be slightly easier for Plan C than for Plan B-2, but neither was difficult.

79,000 cfs, old lock - The tow was eased slowly out of the lock and along the guide wall (Plate 88). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid ground, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

100,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 89 and 59) indicated no appreciable differences between the two plans. In the operation of the model tow, the lateral set toward the right descending bank line experienced as the tow came out toward midchannel appeared to be somewhat less for Plan C than for Plan B-2.

100,000 cfs, old lock - The tow was eased slowly out of the lock and along the guide wall (Plate 90). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid ground, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

155,000 cfs, new lock – The track for Plan C (Plate 91) showed that the tow was not set laterally toward the right descending bank line as much as it was with Plan B-2 (Plate 61). This allowed the tow to get out into the channel and aligned to go through the navigation span of the I-24 bridge farther upstream from the bridge as compared to Plan B-2.

155,000 cfs, old lock - The tow was eased slowly out of the lock and along the guide wall (Plate 92). The tow was steered slightly to the right to get the head of the tow away from the edge of the island. As soon as the head was far enough downstream of the end of the island to avoid ground, the tow could be turned left. The engines were set slow ahead and the rudder turned hard left to allow the tow to get sufficient angle into the current. Once the stern of the tow was about half way down the length of the proposed guide wall, the engines could be brought ahead and the rudder brought back to midship. The tow moved out into the channel and did not have to be steered left until the current started sliding the head of the tow downstream. The tow came out easily into the channel and was easily aligned to go through the I-24 bridge.

300,000 cfs, new lock – The track for Plan C (Plate 93) showed that the tow was not set laterally toward the right descending bank line as much as it was with Plan B-2 (Plate 63). This allowed the tow to get out into the channel and aligned

to go through the navigation span of the I-24 bridge almost a full tow length farther upstream from the bridge as compared to Plan B-2.

300,000 cfs, old lock - The tow was slowly moved out of the lock and along the guide wall (Plate 94). As the stern cleared the lock, the tow was turned left. Once the tow had sufficient angle to go out into the current, usually when the stern was about halfway down the proposed guide wall, the engines were brought up to the permissible power settings and the tow steered out into the current. The current set seemed stronger from the tow coming out of the old lock as opposed to the tow coming out of the new lock with this same flow condition. The tow was maneuvered out into the channel and could be aligned to go through the navigation span with moderate difficulty. Although this condition was more difficult than navigating out of the new lock, it was less difficult than the existing conditions.

370,000 cfs, new lock – The track for Plan C (Plate 95) showed that the tow was not driven as far toward midchannel as was the track for Plan B-2 (Plate 65). This was due to a noticeable reduction in the lateral set toward the right descending bank line with Plan C that didn't require the tow to be driven out quite as far toward midchannel. This allowed the tow to come out at a smaller angle to the alignment of the currents and still allowed the tow to get into position to go through the navigation span with less maneuvering than was required for Plan B-2.

370,000 cfs, old lock - The tow was moved slowly out of the lock along the left side guide wall (Plate 96). As the stern of the tow cleared the divider between the locks, the tow was steered left. This caused the head of the tow to turn out into the channel just downstream of the end of the island. It was easy to get a good angle to go out into the current. The tow easily moved out into the current, out into the channel, and was turned to go through the navigation span with little difficulty. There was no apparent threat to the highway and railroad piers on the right side of the powerhouse island.

Tow tracks, upbound. 35,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 97 and 67) showed equally successful approaches but different approach strategies. There was no apparent change in an upbound approach due to the Plan C training works.

35,000 cfs, old lock - The tow was maneuvered through the bridge and past the mooring cells (Plate 98). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. Controlling the amount of the slide with right rudder was easy. As the tow got into the slack water of the lock approach the head stopped sliding and the engines had to be slowed to reduce speed. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

79,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 99 and 69) indicated no apparent differences between the plans. It was noted in the operation

of the model tow that the current set toward the right descending bank line was reduced as compared with Plan B-2 and required that the tow be steered toward the right descending bank. This was not a problem but was somewhat different than conditions noted for Plan B-2.

79,000 cfs, old lock - The tow was maneuvered through the bridge and past the mooring cells (Plate 100). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. Controlling the amount of the slide with the right rudder was easy. As the tow got into the slack water of the lock approach the head stopped sliding and the engines had to be slowed to keep the tow from accelerating. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

100,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 101 and 71) indicated no appreciable differences between the plans. As with the 79,000-cfs flow condition, it was noted that the current set toward the right descending bank line was reduced as compared with Plan B-2 and required that the tow be steered toward the right descending bank line to get the tow on the guide wall. This added no difficulty to the upbound approach.

100,000 cfs, old lock - The tow was maneuvered through the bridge and past the mooring cells (Plate 102). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. Controlling the amount of the slide with right rudder was easy. As the tow got into the slack water of the lock approach the head stopped sliding. The stern was steered to get the head of the tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

155,000 cfs, new lock – The track for Plan C (Plate 103) showed that the tow was driven slightly further upstream than it was for Plan B-2 (Plate 73) before using the current to push the tow toward the right descending bank line. This was done in anticipation of a possible increase of the current along the west bank of the powerhouse island with the Plan C condition. As noted with the 79,000 and 100,000-cfs flow conditions, the strength of this current and the lateral set was somewhat diminished as compared with Plan B-2 and required the tow to be more actively steered toward the right descending bank line than was the case with Plan B-2. This again created no increase of difficulty and the approaches with Plan C were no more difficult than with Plan B-2.

155,000 cfs, old lock - The tow was maneuvered through the bridge and past the mooring cells (Plate 104). The tow was steered more or less directly into the current, allowing a little slide toward the right descending bank. At approximately one tow length from the end of the island, the tow was steered slightly left and the tow started sliding. Controlling the amount of the slide with the right rudder was easy. As the tow got into the relatively slack water of the lock approach the head stopped sliding. The stern was steered to get the head of the

tow aligned with the guide wall. Once this was done, it was easy to steer the stern into alignment and drive the tow slowly onto the guide wall and into the lock.

300,000 cfs, new lock – The track for Plan C (Plate 105) showed that the tow was steered further toward the left descending bank line and slightly further upstream before using the current to turn the tow toward the right descending bank line than with Plan B-2 (Plate 75) in anticipation of a possible increase of current strength as a result of the Plan C training works. In reality, the current set was somewhat less than that with Plan B-2 and required that the tow be more actively steered toward the right descending bank line. This didn't increase the difficulty of the upbound approach. The approach conditions and difficulty of the approach for Plan C was similar to that of Plan B-2.

300,000 cfs, old lock – The tow was maneuvered upstream through the I-24 bridge and past the mooring piers as normal (Plate 106). Once the tow was from 1 to 1.5 tow lengths from the end of the island, the tow was steered slightly left and the current slid the tow toward the right bank. Controlling the slide with the right rudder was not difficult. As the head of the tow reached the end of the island, the tow was aligned with the guide wall. The tow was driven slowly and maneuvered to keep the head near the island. As the head got to within about 400-500 ft of the end of the guide wall, the engines were reversed to slow the tow. The tow was flanked to the right to keep the stern near the bank and help get the head of the tow inside the alignment of the guide wall. Once the head was on the guide wall, the engines were brought forward slowly and the tow moved along the guide wall and into the lock. There were no tendencies for the tow to move toward the bridge piers in a manner that might be threatening.

370,000 cfs, new lock – The tracks for Plan C and Plan B-2 (Plates 107 and 77) showed that the tow was steered slightly farther toward the left descending bank with Plan C before using the current to turn the tow toward the right descending bank. There was a noticeable decrease of the current set with Plan C that required that the tow be more actively steered toward the right descending bank line. This wasn't difficult and didn't increase the difficulty of the approach as compared to Plan B-2.

370,000 cfs, old lock – The tow was driven upstream through the I-24 bridge and past the mooring cells as was normally done (Plate 108). Once the tow was about 1 to 1.5 tow lengths from the end of the island, the tow could be steered slightly left and the current would cause the tow to slide left. It was easy to control the amount of slide by applying the right rudder. As the tow got into alignment with the lock with the head just downstream of the end of the island, the slide on the head of the tow was diminished and engine power had to be reduced to control the speed. The tow was maneuvered to keep the head aligned with the guide wall. The flow over the end of the island tended to cause the stern of the tow to slowly be pushed toward the right bank. This was not difficult to control. As the head of the tow reached the downstream end of the guide wall, the tow was angled slightly toward the guide wall to keep the head of the wall. As the head moves down the wall, the stern could be steered toward the island. The tow was aligned to enter the lock by the time the head reached the lock opening. There was no tendency for the tow to threaten the bridge piers while under powered control.

It could be noted in some of the upbound tracks with Plan C that the tow was steered more toward midchannel, then turned slightly left to let the current slide the tow toward the right descending bank and into the lock approach, which is a typical approach used at similar sites (Personal Communication, 30 March 2000, Charlie Ritchie, Vulcan Materials, Inc.). This approach was used for all the upbound approaches with Plans B-2 and C. It was noted for all of the flow conditions examined with Plan C that the tendency for the tow to be set toward the right descending bank line was lessened as compared with Plan B-2. This allowed the tow to be driven more directly upstream, and then using the current (and somewhat more left rudder than with Plan B-2) to slide the tow across the channel and into the lock approach. The reduction of the tendency for the tow to be set toward the right descending bank line with Plan C required slightly less corrective steering than with Plan B-2. The overall approach with either plan was not difficult but Plan C appeared to provide slightly better conditions than with Plan B-2.

Water-Surface Profiles

Description

During the operation of each flow condition for each major plan, including the base conditions, water-surface elevations were recorded using the piezometer locations as shown in Figure 2. The water-surface elevations are listed in Table 1.

Results

The water-surface elevations as recorded during the various plan conditions indicate that there was little effect on the water surface by the addition of any of the evaluated plans. The largest increase in water surface was 0.3 ft in the area immediately adjacent to the Plan C training works just downstream of the spillway with the 100,000-cfs flow condition. The water surface had returned to approximately the same elevations as with the base condition near the end of the powerhouse island. For all other conditions the water-surface elevations usually varied by 0.2 ft or less.

Proposed Left Bank Fishing Jetties

Description

Near the completion of work with Plan C, the Nashville District provided ERDC with a new design for the proposed left bank fishing jetties. This design called for two jetties, the most upstream jetty 90-ft long, and the downstream jetty 110 ft, spaced approximately 225 ft apart, on the left descending bank line starting approximately 245 ft downstream of the existing left bank jetty. These jetties were the most current design that superceded the originally proposed design of three, approximately 70-ft jetties, spaced approximately 125 ft apart. To determine if these fishing jetties might cause unforeseen navigation

difficulties, the model was returned to the same conditions as that of Plan B-2 with the exception of the left bank fishing jetties (Figure 19).

The greatest concern for upbound traffic was that the proposed fishing jetties would increase the difficulty in getting onto the left bank mooring cells. To examine this, the upbound tow was maneuvered through the I-24 bridge then over to the left descending bank and onto the mooring cells, once control was established, the tow was maneuvered off the cells and back out into the channel. Once the tow was off the cells and out into the channel, the upbound runs were terminated. For the downbound tows, it was determined from examination of tow tracks from the previous testing that tows coming from the existing lock were more likely to be influenced by any change in current patterns caused by the proposed fishing jetties than tows coming from the proposed lock. For the downbound tracks, the tows were brought out from the existing 600-ft lock and once the tow had successfully passed the channel adjacent to the fishing jetties and passed through the I-24 bridge, the runs were terminated.

Results, navigation conditions

Current directions and velocities. For the 35,000 and 79,000-cfs flows (Plates 109 and 110) the fishing jetties had no apparent influence on current patterns. For the 100,000-cfs flow (Plate 111) the upstream jetty was diverting flow toward the channel and the flow came back toward the left descending bank line as it passed the downstream jetty. Flow past the mooring cells remained parallel to the flow in the channel. For the 300,000 and 370,000-cfs flows (Plates 112 and 113) the jetties appeared to have little effect on the pattern of flow, especially near the mooring cells.

Tow tracks, downbound. 35,000 cfs – The tow moved easily out of the lock and out into the channel (Plate 114). The tow was completing the turn back to the right to get aligned with the navigation span at the time it passed closest to the fishing jetties. There was no apparent effect from these jetties.

79,000 cfs – As with the 35,000-cfs flow, the tow moved out of the lock and turned to get out into the channel without difficulty (Plate 115). The tow was in the process of being turned back to get into alignment with the navigation span at the time it passed closest to the fishing jetties, but there was no apparent effect on the tow.

100,000 cfs – The tow moved out of the lock and started the left turn to get into the channel with no difficulty (Plate 116). The tow was able to turn back to the right and get into alignment with little difficulty. In comparison with the tow runs made with the Plan B-2 with the originally proposed three jetties (Plate 60) there was no appreciable differences due to the new jetty plan.

300,000 cfs – The tow moved out of the lock and immediately after passing the end of the powerhouse island, the tow was turned sharply left to get enough angle to get out into the strong current (Plate 117). As the tow came abreast of the most upstream mooring cell, the tow was out sufficiently into the channel so that it could be turned into alignment with the navigation span. There were no

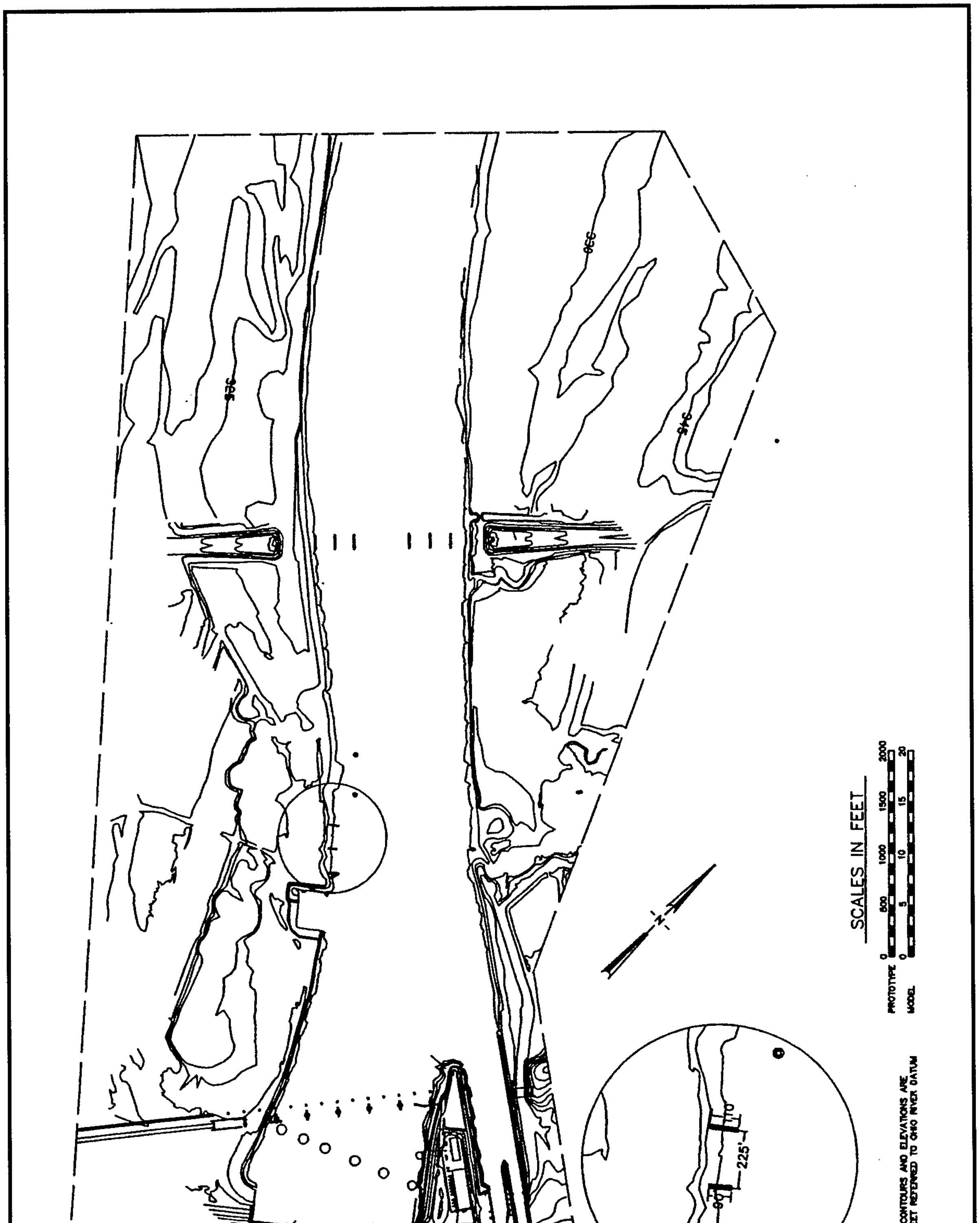


Figure 19. Left bank fishing jetties

appreciable changes to maneuvering required or difficulty due to the proposed left bank jetties.

370,000 cfs – As with the 300,000-cfs flow condition, the tow was turned sharply left after clearing the powerhouse island (Plate 118). The current set was not quite as strong and the tow got out into the channel sufficiently when the head of the tow was about one-half tow length upstream of the uppermost mooring cell. There was no noticeable change in maneuvering or difficulty due to the proposed jetties.

Tow tracks, upbound. 35,000 cfs – The tow had no difficulty in moving upstream through the I-24 bridge and onto the mooring cells (Plate 119). Getting off the cells only required turning the rudders to the left and applying engine power. The head came off the upstream cell easily and rotated channelward.

79,000 cfs – The tow had little difficulty in getting upstream of the I-24 bridge, approaching, and getting onto the mooring cells (Plate 120). It was also easy to rotate the tow off the downstream cell, get separation from the upstream cell, and then start the tow sliding away from the cells by using the current.

100,000 cfs – The approach to the mooring cells was not difficult (Plate 121). The strength of the current made it easy to get the tow off the mooring cells and out into the channel. The deflection of current noted in the current directions and velocities was not noticed in the operation of the tow.

300,000 cfs – The strong current required the approach to be made slower and with more caution, but the approach was not unnecessarily difficult for the flow conditions attempted (Plate 122). There was no noticeable effect from the fishing jetties.

370,000 cfs – As with the 300,000-cfs flow, the approach was made slowly and with caution, but did not require any unduly difficult maneuvering (Plate 123). There were no noticeable effects from the fishing jetties.

Railroad Truss Float-in

Description

During construction of the proposed lock and guide wall, the proposed highway and railroad bridges are to be built and put into operation. As part of the construction of the proposed railroad bridge, the truss that is to span the downstream navigation approach to the existing and proposed locks is to be built remotely then moved into position. The truss is to be built in the left bank boat basin, which will be enlarged along the upstream side to a total width of approximately 350 ft. The truss is to be constructed on temporary bents placed in the basin. When construction is completed and flow conditions are within the specified limits of discharge and stage as defined by the Nashville District contract specifications, two barges, each 160-ft long and 54 ft wide, will be brought into the basin, positioned near each end of the truss, and partially filled with water to weigh them down. A set of temporary bents will be constructed between the

barges and the truss. When this is completed and flow conditions are within specified limits, the water will be pumped from the barges and the truss will be lifted free from the construction bents. A towboat is to be placed on each barge and the barges are to be backed out of the basin sufficiently to allow the connecting member between the head of the two barges to be reattached after the head of the barges are channelward of the construction bents. The barge/truss configuration will then be backed out into the channel. The barge/truss configuration must be rotated to face upstream, move from the left descending bank line toward the right descending bank line, steer around the existing mooring cells immediately downstream of the powerhouse island, and move into position between the bridge piers. Once in position, the barges will again be filled with water and the truss will be set onto the bridge piers, one on the powerhouse island and the other landward of the proposed guide wall. Also, a high-tension powerline spans the river approximately 600 ft downstream of the boat basin. The height of the barge/truss configuration will be sufficient to strike the lowest point on these powerlines, therefore the configuration must be turned and the downstream drift with the current stopped before the truss reaches the powerlines.

To determine how this maneuver could be performed and the difficulties that might arise in performing the maneuver, a simplified scale replica of the barge/truss configuration was constructed and the left bank boat basin was enlarged to specifications received from the Nashville District in September 2000. The barges were built to the correct dimensions and the bents that would support the truss were installed in the correct position within the barge and in the correct position on the truss. The replica of the truss was with a rectangular beam having the correct width and length dimensions and weighted sufficiently for the barges to draft the specified 7 ft. Two radio-controlled model towboats, one for each barge, were used and were independently operated. The features of this plan were illustrated in Figure 20.

The flow conditions under which the barge/truss configuration was to be moved are limited, especially the tailwater elevation. If the tailwater is too low, the truss cannot clear the top of the bridge piers and the channel near the entrance to the boat basin will require dredging to remove some shallow areas. Dredging is to be avoided due to the environmental impacts on adjacent mussel beds. If the tailwater is too high, the truss cannot be lowered sufficiently to put it into place once it was in position in the lock approach. To achieve the correct tailwater elevation, it was proposed that the truss be placed during low-water season. To regulate the tailwater elevation, the upper pool at Lock & Dam 52 on the Ohio River can be raised or lowered and the flow through the powerhouse at Kentucky Lock & Dam can be increased or decreased temporarily or a combination of both. The absolute conditions that might exist at the time of the truss placement were unknown; therefore, a range of flow and tailwater conditions was provided to ERDC.

The flow conditions that were provided by the Nashville District for evaluation of the truss float-in are as follows:

a. 301.5-ft tailwater (slack flow), increase powerhouse discharge as necessary to raise tailwater elevation to 303.0 ft.

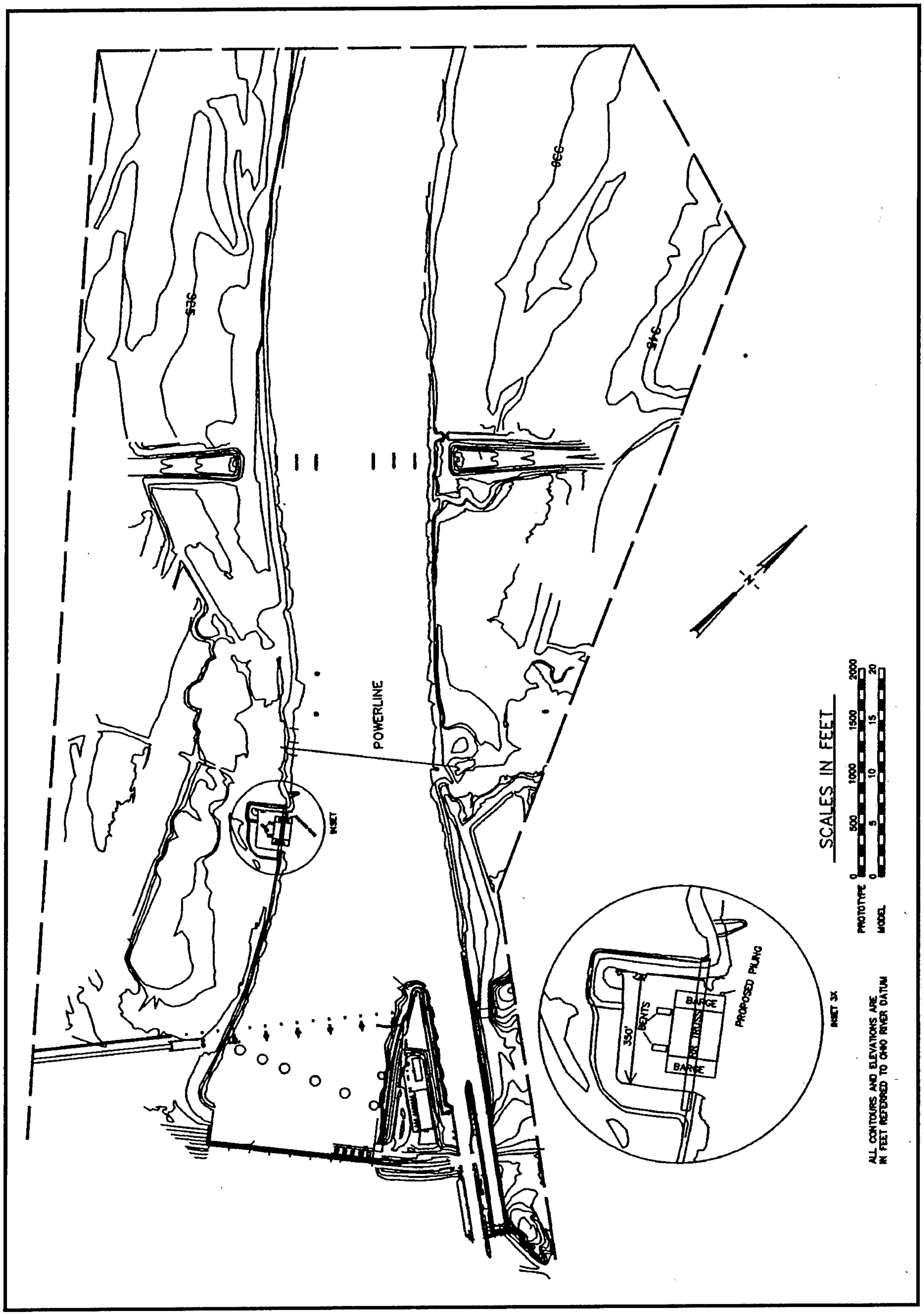


Figure 20. Railroad truss float-in conditions

b. 303.0-ft tailwater (slack flow), no discharge through powerhouse or dam.

c. 300.0-ft tailwater (slack flow), increase powerhouse discharge as necessary to raise tailwater elevation to 303.0 ft.

d. 306.0-ft tailwater with 75,000-cfs discharge, reduce powerhouse discharge to lower tailwater elevation to 303.0 ft.

The model was calibrated to determine the discharges through the powerhouse necessary to obtain the specified tailwater elevations. Once these flow conditions were calibrated, current directions and velocities were obtained. After collection of current directions and velocities, a beam was placed across the model to mark the position of the high-tension powerlines. The overhead tracking system was used to track the model barge/truss configuration as it was maneuvered from the boat basin until it reached a position in alignment with the railroad piers in the lock approach. Also, the operation of the model barge/truss configuration was videotaped as the maneuver from the boat basin to alignment with the railroad bridge piers was performed for each flow condition.

For flow conditions c and d, the strength of the current immediately outside of the boat basin pushed the barge/truss configuration to the downstream edge of the basin before it could be backed from the basin. Two approaches to controlling the downstream set of the barge/truss configuration before it could be backed from the basin were evaluated. The first approach was to connect lines to the head and the stern of the upstream barge. These lines were slowly released to keep the configuration from being set downstream before the configuration was out sufficiently far from the boat basin to start rotating, and then completely released when the configuration started rotating. The second approach was to install a single piling at the downstream channelward corner of the boat basin. This piling could be used to hold the configuration in place and as a pivot for the downstream barge to work from as the configuration rotates. Since the amount of current set for flow conditions a and b was small enough that the barges could be backed out without danger of setting into the downstream edge of the basin, the lines holding the configuration in place for these flow conditions was completely released as the towboats started backing.

Results, navigation conditions

Current directions and velocities. 301.5 to 303.0 tailwater (TW)– Currents tended to cross from about two-thirds of the length downstream along the west edge of the powerhouse island toward the left descending bank line, reaching the left descending bank line about 500 ft upstream of the upper end of the boat basin, then turn directly downstream (Plate 124). The current still slightly angled toward the left descending bank line as they passed the boat basin. The velocities just outside the basin ranged from 1.6 to 3.4 fps. A large area of almost slack current extended from midchannel to the right bank and up into the lock approach.

303.0, no flow – The model was not designed to hold a flat pool with no discharge, so enough flow was passed through the powerhouse to maintain the required pool, and so there was some flow and velocities. The current direction

was similar to that of the previous flow condition (Plate 125). Velocities immediately outside the boat basin were from 0.8 to 1.1 fps and the area of almost slack velocities was slightly larger than the previous flow condition.

300.0 to 303.0 TW – The currents tended to cross the channel starting about two-thirds of the length downstream of the powerhouse island and reaching the left descending bank line at the upstream edge of the boat basin (Plate 126). The currents out into midchannel directly outside the boat basin still tended to be angled toward the left descending bank line. The velocities immediately outside the boat basin ranged from 2.4 to 4.5 fps and the slack water area extended from the right bank to about 40 percent of the total distance across to the left bank and ended about 200 ft downstream of the end of the guide wall.

306.0 to 303.0 TW – The currents angled across the channel from about two-thirds of the length downstream of the powerhouse island and reached the left descending bank line about 500 ft upstream of the upper end of the boat basin (Plate 127). The currents along the left bank tended to parallel the bank but out in the channel they tended to be angled slightly toward the left bank. The velocities immediately outside the boat basin ranged from 3.9 to 4.8 fps and the slack water area was confined from the right bank line out to about 25 percent of the total width of the channel and back into the lock approach.

Tow tracks. 301.5 to 303.0 TW – Both towboats backed their engines to start the barges out of the basin (Plate 128). As the barges cleared the basin, the current push on the most upstream barge and towboat caused the barge/truss configuration to rotate counterclockwise. The left side towboat then changed direction of the engine to start driving. This was done to control the rate of rotation of the barge/truss configuration. The right towboat continued backing slowly to move out into the channel. As the configuration rotated sufficiently that it was facing upstream, the right towboat started driving forward. The left side towboat applied more engine power to stop the rotation of the barge/truss configuration. As the rotation was stopped, the engine power to both towboats was balanced so that the configuration moved slowly forward. The barge/truss configuration was rotated slightly toward the right descending bank line and the current caused the configuration to slide toward the right bank. It was not difficult to slide toward the right bank sufficiently to get landward of the old mooring cells downstream of the powerhouse island. By this point, the configuration was in mostly slack currents and it was not difficult to move up into the lock approach and position the truss.

303.0 TW, no flow – Both towboats backed their engines to start the barges out of the basin (Plate 129). As the barges cleared the basin, there was little current to assist in the rotation of the barge/truss configuration or to set the configuration downstream into the powerline. The left towboat continued to back until the rotation to alignment upstream was about half complete, then the engine direction was changed to forward to slow the rate of rotation. The engine of the right towboat was brought forward as the rotation to face upstream was completed. With little current to help the configuration slide, the configuration had to be rotated slightly toward the right descending bank line and the towboats were driven and steered left to get landward of the mooring cells. Once the

configuration was between the right bank and the mooring cells, it was not difficult to move into the lock approach and position the truss.

300.0 to 303.0 TW, with lines – Both tows were backed slowly (Plate 130). The barge/truss configuration tended to try and rotate counterclockwise. The right side towboat used its left flanking rudder to counteract this rotation and keep the lines taut. The bowline was held and the stern line slowly released so the barge/truss configuration pivoted off the upstream line. As the head of the barges neared the entrance of the boat basin the stern line was released, the right towboat was backing slowly and the left tow was driving slowly. As the head of the upstream barge got about 20-30 ft outside the basin, the line on the head of the barge was released. The configuration immediately started drifting downstream and rotating. The right towboat engine was brought ahead to help hold the position on the right side and the left towboat engine was brought ahead to control the rate of rotation. As the configuration turned sufficiently to be facing directly upstream, both towboats increased power to stop the current set downstream. As the configuration was rotated slightly toward the right descending bank line, the tow slid easily and was not difficult to get landward of the mooring cells. Once between the mooring cells and the right bank, the configuration was not difficult to maneuver into the lock approach and into position for the truss.

300.0 to 303.0 TW, with piling – Lines were placed on the head and stern of the upstream barge to hold it in place until the barge/truss configuration was ready to be backed out (Plate 131). When ready, the lines were released and the right towboat backed slowly. The current caused the configuration to start rotating counterclockwise. The right side barge backed alongside the piling and the configuration pivots around the piling. The left towboat engine was brought ahead immediately to control the rate of rotation of the configuration. The configuration pivoted off the piling and was set downstream. As the head of the downstream barge cleared the piling, the right towboat engine was brought ahead to help control the rate of the downstream set. As the configuration rotated sufficiently to be facing directly upstream, the engine power of both towboats was increased to stop the downstream set and gain forward momentum. The tow was turned slightly toward the right descending bank line and the configuration slid easily toward the right bank. Maneuvering landward of the mooring cells, into the lock approach, and into position for the truss was not difficult.

306.0 to 303.0 TW, with lines – The maneuver using the lines was similar to that described for the 300.0 to 303.0 TW condition (Plate 132). The current set was greater and it proved to be more difficult to get the barge/truss configuration out of the boat basin. The downstream set of the current pushed the configuration downstream before rotation could be started. Turning the configuration before reaching the powerline required that the configuration be rotated faster than that done with the 300.0 to 303.0 TW condition. Once the rotation was completed and the downstream set stopped, maneuvering the configuration around the mooring cells and into position for the truss to be set was not difficult.

306.0 to 303.0 TW, with piling - The maneuvers with the piling were similar to that performed with the 300.0 to 303.0 TW condition (Plate 133). The barge/truss configuration rotated off the piling and out into the channel with little difficulty, control of the downstream set and the rate of rotation were easy, and

sliding the configuration landward of the mooring cells and into position to set the truss was not difficult.

Powerhouse Island Pier Impacts

Description

The bridge piers for the proposed highway and railroad bridges that will serve as the west side support for the spans over the downstream approach to the locks are to be placed near the eastern edge of the powerhouse island. During periods of high tailwater, these piers will be inside the waterline and the depth of water around them will be sufficient that barges can reach them. The design for these piers does not include any type of fendering or protection. To determine the likelihood of a tow striking the piers and the speed, angle, and point along the tow that might impact the piers, a series of tow runs were made in the model.

In the preliminary examinations, it was determined that the only flow condition used for model evaluations that had sufficient water depth around the piers that loaded barges could reach them was 370,000 cfs with a 344.0-ft tailwater. It was also determined that downbound traffic from either lock had almost no possibility of striking the piers, so efforts were concentrated on upbound traffic only.

Upbound approaches made to either lock with the tow having full engine and rudder control capability determined that there was little opportunity for the piers to be struck (Plates 75-78 and 105-108). The greatest potential for striking the bridge piers appeared to be if the upbound tow lost engine and/or rudder control immediately downstream of the powerhouse island and the momentum carried the tow into the piers. Tows making approaches toward the proposed lock typically were angled away from the powerhouse island and have almost no tendencies to drift back toward the island and potentially threaten the bridge piers. The greater likelihood for potentially reaching the bridge piers was on approaches toward the existing 600-ft lock; therefore, the documentation of bridge impacts was based on upbound approaches to the existing lock.

To document the likelihood of hitting the bridge piers, a series of tow runs was made. During the preliminary evaluations, it was observed that upbound tows had to come within 600 to 800 ft of the downstream end of proposed guide wall before shutting down engines and steering to have sufficient momentum to reach the area near the bridge piers. It was also observed that the tow needed to be within a relatively small band of distance from the right descending bank line to have the highest potential of striking the piers. Positions were marked on the model at 600 ft and 200 ft downstream of the lower end of the proposed guide wall and laterally from the right descending bank line to use as a reference point at which to aim the tow on the upbound approaches and to shut off all power and steering. The tow was driven upstream with efforts made to keep approximately the same speed, approach angle, and lateral position away from the right descending bank line for each tow run. The overhead tracking system was used to record the position of the tow and from this information, the speed, angle of heading, lateral distance from the right descending bank, and distance from the

downstream end of the proposed guide wall at the time engine power and steering was shut down were obtained. The tow was allowed to drift until it stopped or struck an object. The tracking system was used to obtain the speed and angle of the tow when it struck an object and visual observation was used to record which object was struck and at what position along the head or side of the tow was impacted. A total of 25 runs were made for each position downstream of the guide wall for both the Plan B-2 and Plan C conditions, a total of 100 runs. The information obtained from these runs was presented in tabulated form in Tables 2-5. Due to the large number of runs made, track plots were not included in this report.

Results

For Plan B-2 with the release point 600 ft from the end of the guide wall (Table 2), only one of the 25 runs hit the railroad pier with the head of the tow. At the 200-ft release point (Table 3), six of the 25 runs hit either the highway or railroad pier with the head of the tow.

For Plan C with the release point 600 ft from the end of the guide wall (Table 4), five of the 25 runs hit either the highway or railroad piers with the head of the tow. From the 200-ft release point (Table 5), four of the 25 runs made hit the railroad pier.

The impact velocity for all the runs with both plans and from both release areas was 1.6 fps or less with most impacts being less than 1.0 fps. The bridge piers were designed to absorb the load from minor impacts of tows. The small period of time that the tailwater was high enough for loaded barges to reach the piers, the small number of head on impacts documented in the model runs, and the small chance that a tow would lose all maneuvering capability while in the upbound approach to the existing lock indicate an extremely small likelihood of an impact to the piers and an even smaller likelihood of any significant damage to the pier.

Point Velocities at Bridge Piers and Training Structures

Description

During evaluations of the various plans examined in the model, the Nashville District requested that localized velocity information be obtained around the proposed bridge piers, proposed training dike (Plan B-2), and near the proposed spillway training works (Plan C). These velocities were to be used to help determine sizing of the stone protection needed for the bridge piers and size of stone needed to construct the training works.

These velocities were obtained using the ADV meter. This probe uses acoustic sensing techniques to measure flow in a remote sampling volume which was undisturbed by the presence of the probe. The Froude velocity relationship

for the model to prototype is: $V_{Proto}/V_{Model} = (Scale_{Model})^{1/2}$. The Kentucky Lock and Dam model was an undistorted scale of 1:100 so therefore; the velocity relation of the prototype to the model was a factor of 10. The ADV probe records actual model water velocity in feet per second and a post processing routine then converts the model velocities into the equivalent prototype velocity. Velocities were typically recorded at several depths near each structure and were sampled at a frequency of 10 times per second for 120 sec or more at each data collection point to obtain the highest velocity and to average out the rise and fall in velocity values noted in discreet data points due to random turbulence. The positions at which the velocities were recorded are illustrated in Figure 21.

Results

The point velocity data was obtained for:

a. Spillway with Plan B-2 conditions (Table 6).

b. Spillway velocities with Plan C conditions (Table 7).

c. Velocities upstream of highway and railroad bridge piers, Plan B-2 (Tables 8–9).

d. Velocities upstream of highway and railroad bridge piers, Plan C (Tables 10-11).

e. Velocities near the downstream end of Plan B-2 training work (Plate 12).

f. Velocities near the downstream end of the angled dike for Plan C (Plate 13).

g. Velocities upstream of highway and railroad bridge piers with tailwaters from 300.0 to 310.0 (Tables 14-15).

The gates of the dam were numbered right to left, starting at the powerhouse. The numbers of the highway and railroad piers were left to right, starting at the first piers on the left descending overbank.

Point Velocities in Water Column

Description

Changes made as a result of construction of the new lock, relocation of the railroad and highway bridges, possible training works for navigation improvements, and changes in operation of the spillway gates to reduce gas saturation and recirculation may influence currents through the water column and affect the mussel bed habitats below the spillway. To establish baseline conditions, a series of point velocities were taken at five cross sections in the model. An ADV meter was used to measure velocities at depths of 2, 4, 6, and 10 ft from the bottom, where sufficient water depth was available, for all flow conditions. This information was to be gathered during each significant plan change to allow comparison of velocities of the base configuration with the plan configurations at the various depth levels for each flow condition.

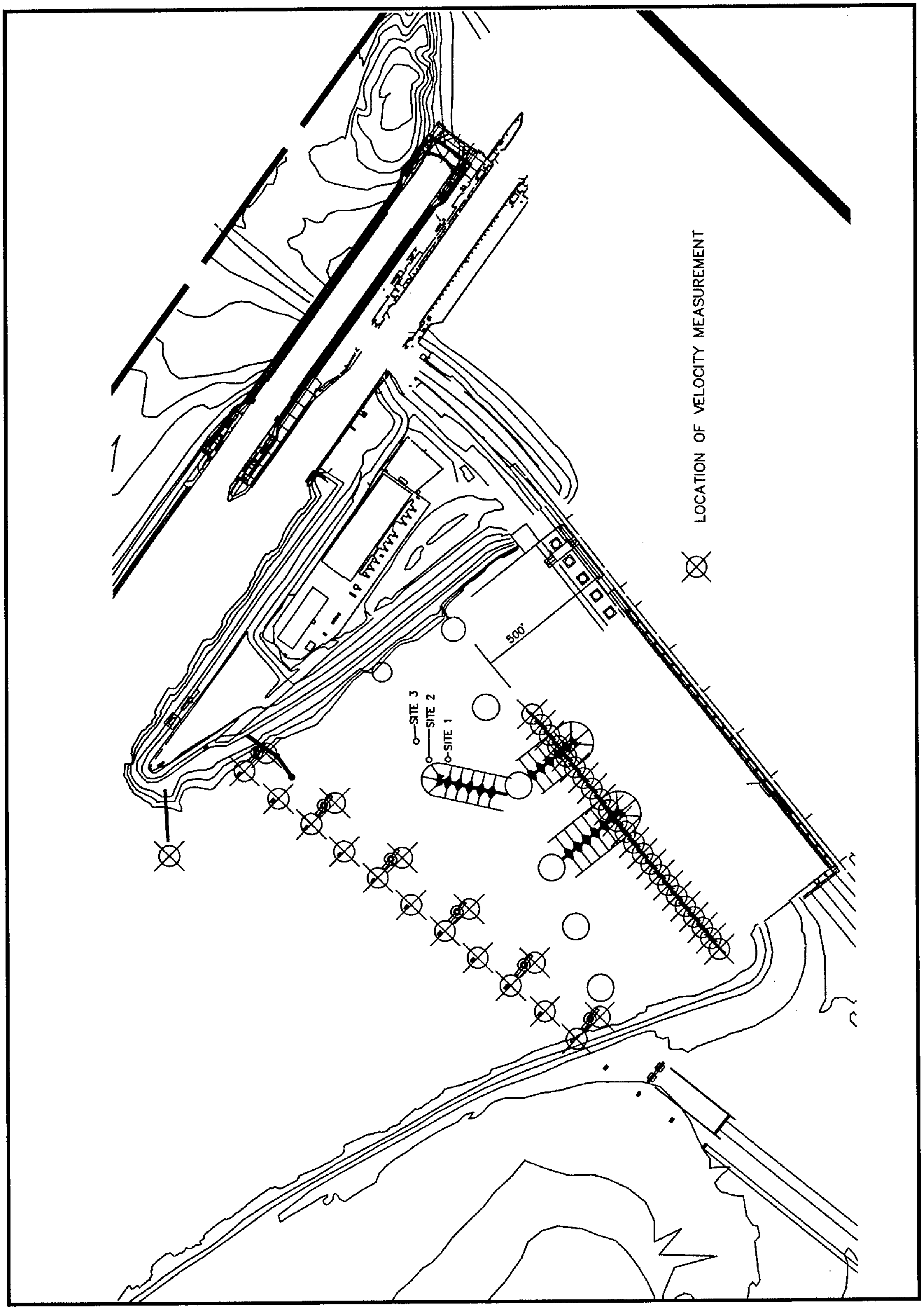


Figure 21. Point velocity collection sites

During discussions prior to the model's construction of what data was to be obtained from the model, it was agreed that point velocities through the water column should be taken during model testing. These velocities were to be taken with the existing conditions (base test) and compared to the plan conditions after installation of the proposed 1,200-ft lock, highway and railroad bridges, fishing piers and jetties, and any training works necessary to improve navigation conditions in the lower lock approach and/or recirculation conditions in the spillway. Changes in the velocities would be used as an indicator of how these proposed changes might affect the mussel beds that are habitats along both banks below the dam.

Initially velocities were collected at four points along the right descending bank line and three along the left, a total of seven points. The velocity was to be sampled at 2, 4, 6, and 10 ft from the channel bottom at each collection site. During meetings in August 1999, ERDC was requested to obtain velocity data in cross sections with points approximately spaced every 250 ft across the channel and add a cross section approximately 600 ft downstream of the most downstream point collected up to that date; a total of five cross sections (Figure 22). A set of velocities was obtained at all the collection points, all the flow conditions, and for all four distances from the bottom, where depth in the model permitted for the base conditions. The velocity data, collected in September 1999, was processed and examined and appeared to be reasonable.

The point velocities collected for Plans B and B-1 were completed in May 2000. Once these data were processed and compared with each other and with the base condition data, anomalies were noted. The average velocities were presented in Tables 16-20. Some of the anomalies noted were large differences in velocities between the base conditions and the two plans, especially at 2 and 4 ft from the bottom of the channel (i.e., 300,000 cfs, x-sect 3, point 5) and occasional wide variation of velocities between the base and two plan conditions at any depth (300,000 cfs, x-sect 5, point 6).

Several types of experiments were performed in an effort to determine why the anomalies in data exist and if there were steps that could be taken to reduce or eliminate some of the anomalies. These experiments and their results were described in a letter report that was prepared by ERDC, the Nashville District, and TVA and made available to parties of interest in November 2000.

Results

The overall conclusion from these experiments was that the velocity measurements through the water column near the bottom of the model using the ADV probe were not sufficiently repeatable and reliable enough to be used for analysis purposes for determination of impacts on mussel habitats. At this point, efforts to use and analyze the data that had been collected up to this date and plans to collect additional data were discontinued.

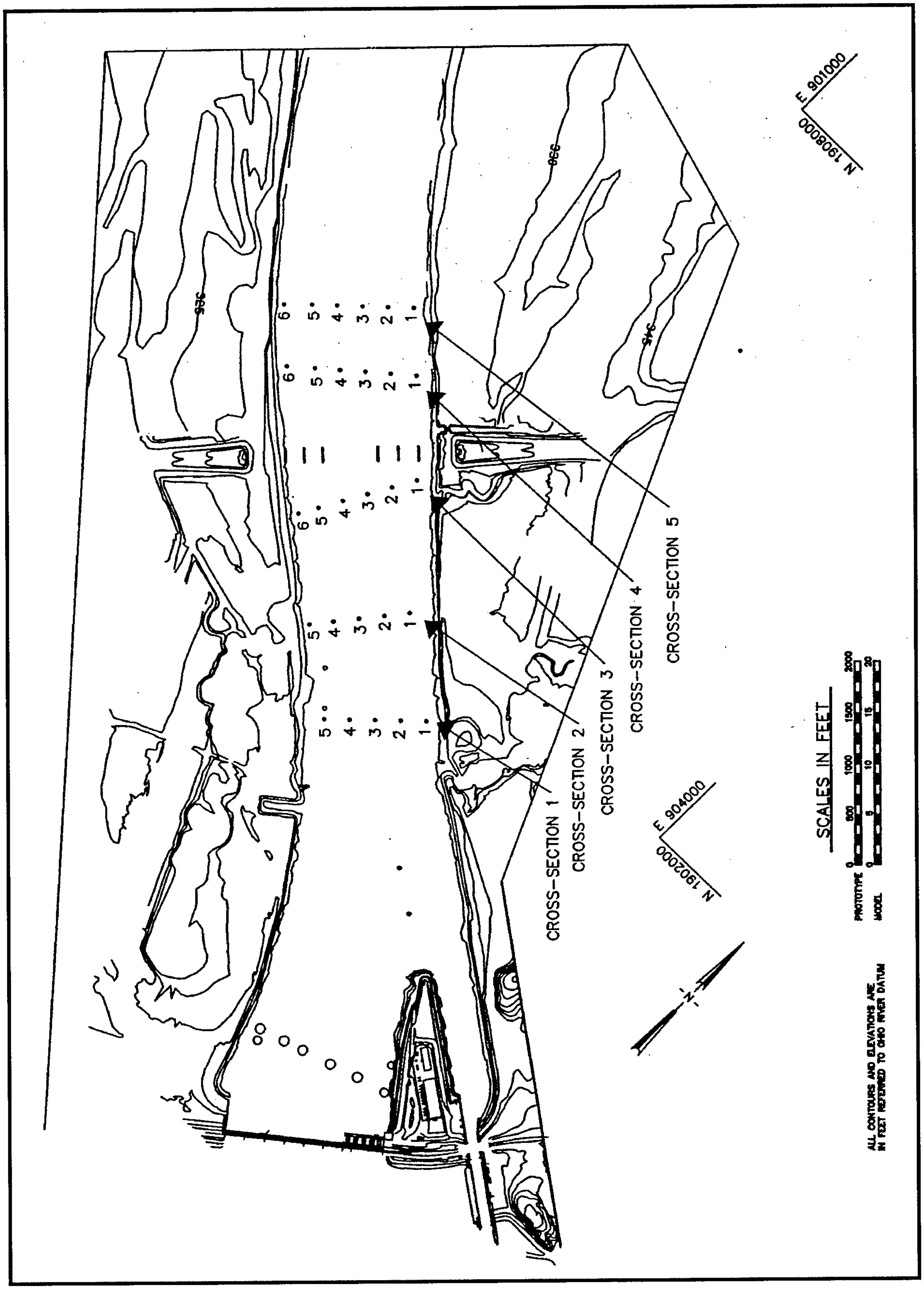


Figure 22. Point velocity in water column collection sites

Navigation Conditions with Cofferdam

Description

It was important to industry to optimize the use of the existing lock as much as possible during the construction of the proposed lock. The plans for construction allow for tow traffic through the existing lock during most of the construction. Certain activities, such as the truss float-in or cofferdam wall segment float-in; will require that navigation through the lock be stopped for some period of time. Once construction of the cofferdam for the proposed lock is started, the approach to the existing lock will be constricted by the placement of guard cells, placement of the float-in cofferdam wall segments, and construction of the full cofferdam.

The Nashville District requested that the model be used to evaluate the navigation conditions during phases of the cofferdam construction and with the completed cofferdam in place. To perform this, the proposed 1,200-ft lock and 1,200-ft guide wall that had been installed for evaluations of Plans A through C were removed. This was required because the two float-in cofferdam wall sections will become a portion of the left wall of the proposed lock. The model bed underneath the proposed cofferdam and right bank from the end of the existing lock to approximately 1,800 ft downstream of the axis of the dam was molded to the precofferdam construction excavation plan. Two 40.74-ft-diam guard cells were installed according to specifications. Two wall segments, one 261 ft long and the other 221 ft long, were fabricated to replicate the two float-in cofferdam wall segments. It was anticipated that the float-in wall segments will be positioned and set during low flow and tailwater conditions; therefore the evaluations performed with only the wall segments in place were limited to the tailwater conditions that were approximately the equivalent of the top of the float-in segment elevation (315.0) or less. Segment 1, the 261-ft section (Figure 23), was placed in the model first and evaluated for the following flow conditions:

Discharge, cfs	Headwater el, ft	Tailwater el, ft
35,000	359.0	300.0
79,000	359.0	303.6
100,000	358.0	306.3

Segment 2, the 221-ft section (Figure 24), was then added to the model and evaluated. Segment 2 was evaluated for the same flow conditions as segment 1, but was also evaluated for:

Discharge, cfs	Headwater el, ft	Tailwater el, ft
155,000	359.0	316.0

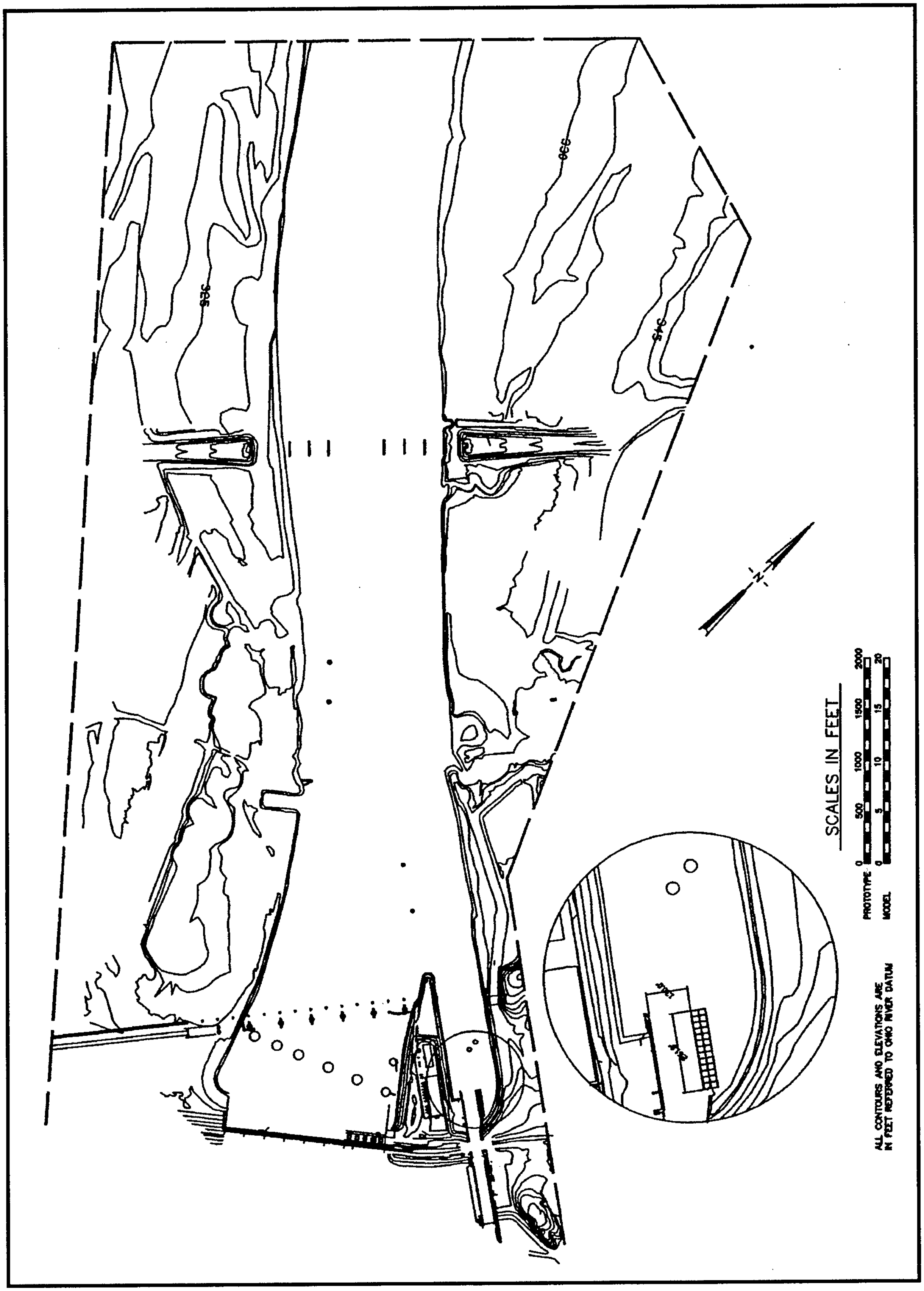


Figure 23. Cofferdam float-in wall segment 1 conditions

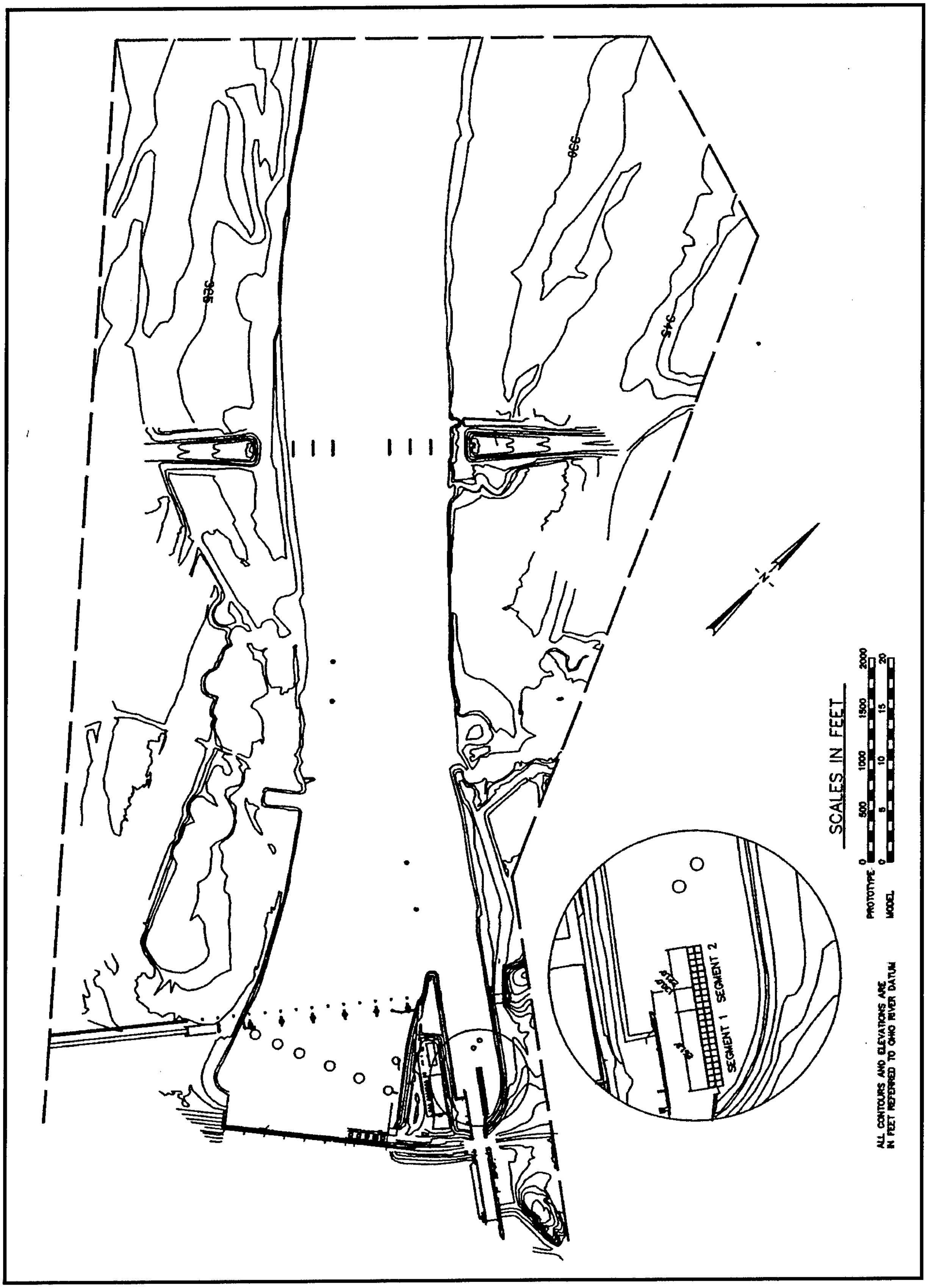


Figure 24. Cofferdam float-in wall segment 2 conditions

Following these evaluations, the Nashville District requested that the model be used to evaluate the navigation conditions with the use of floating camels. These camels are to be floating protection blocks, approximately 30 ft long, 7.5 ft wide, and 5 ft deep that would be placed outside of the unfilled sections of the float-in cofferdam walls at the waterline to provide protection against a tow striking the wall (Figure 25). Upbound traffic would have the greater potential of hitting the float-in wall or of being affected by the camels, so only upbound traffic was evaluated with the camels in place for wall segments 1 and 2.

The full cofferdam plan (Figure 26), which consisted of the two 40.74-ft-diam guard cells, the two float-in walls, three 69-ft-diam cofferdam cells, and sheet piling between the right bank and the landward most cofferdam cell was then installed and evaluated. The final cofferdam plan design, which called for an additional 69-ft cofferdam cell, was completed while the earlier design was being examined in the model. The most recent design changes were not considered to have an impact on the navigation conditions and evaluations; therefore, the most recent cofferdam plan was not installed or evaluated in the model. The full cofferdam plan was evaluated for all six flow conditions that had been used for all previous navigation testing.

During a meeting with towing industry representatives at ERDC in April 2001 to discuss the results of the cofferdam evaluations, the towing industry representatives suggested that the training work developed for Plan B-2 might be beneficial to navigation during the period of construction with the cofferdam in place. Demonstrations made on the model at that time with and without the training work indicated that navigation conditions might be improved with the training work in place. To document how navigation might be improved with the training work, the Nashville District requested that the 100,000-cfs flow condition be evaluated with cofferdam float-in wall segment 2 in place and the 300,000-cfs flow condition be evaluated with the full cofferdam in place. This plan was illustrated in Figure 27.

Results, navigation conditions, cofferdam float-in wall segment 1

Current directions and velocities. For the 35,000-cfs flow (Plate 134) the currents were generally parallel to the bank lines and the slow eddy in the lock approach extended from the downstream end of the powerhouse island diagonally approximately 900 ft toward the right descending bank line. The velocities approximately 1,000 ft downstream of the end of the island ranged from 2.2 to 3.2 fps. For the 79,000-cfs flow (Plate 135) the currents again generally aligned with the bank lines and the eddy in the lock approach extended from the end of the powerhouse island diagonally 1,200 ft toward the right descending bank line. The velocities approximately 1,000 ft downstream of the end of the island ranged from 4.5 to 6.5 fps. For the 100,000-cfs flow (Plate 136) the currents were generally parallel to the bank lines and the eddy in the lock approach more or less paralleled the right bank starting about 100 ft downstream of the powerhouse island and extended approximately 1,000 ft.

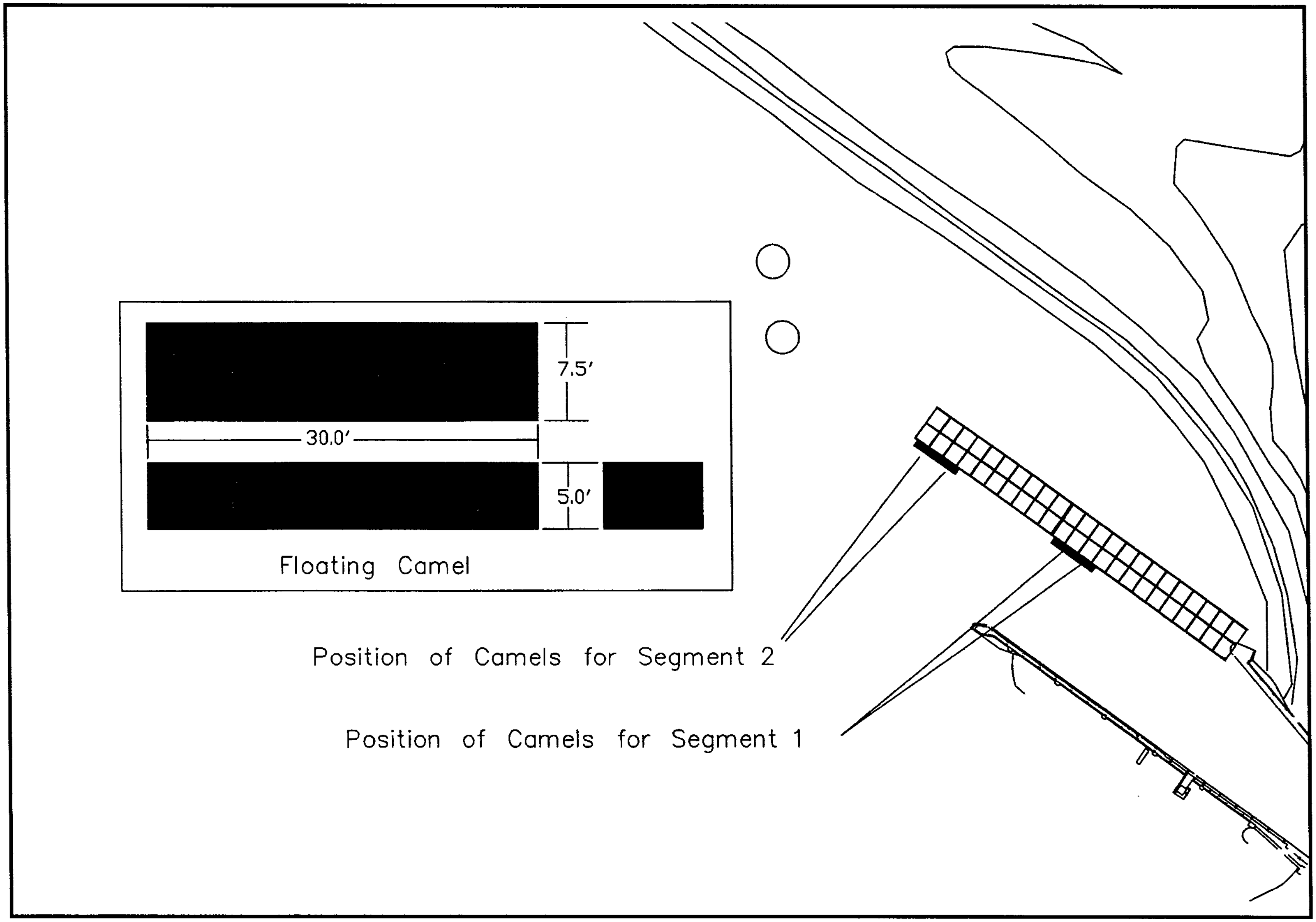


Figure 25. Floating camel locations

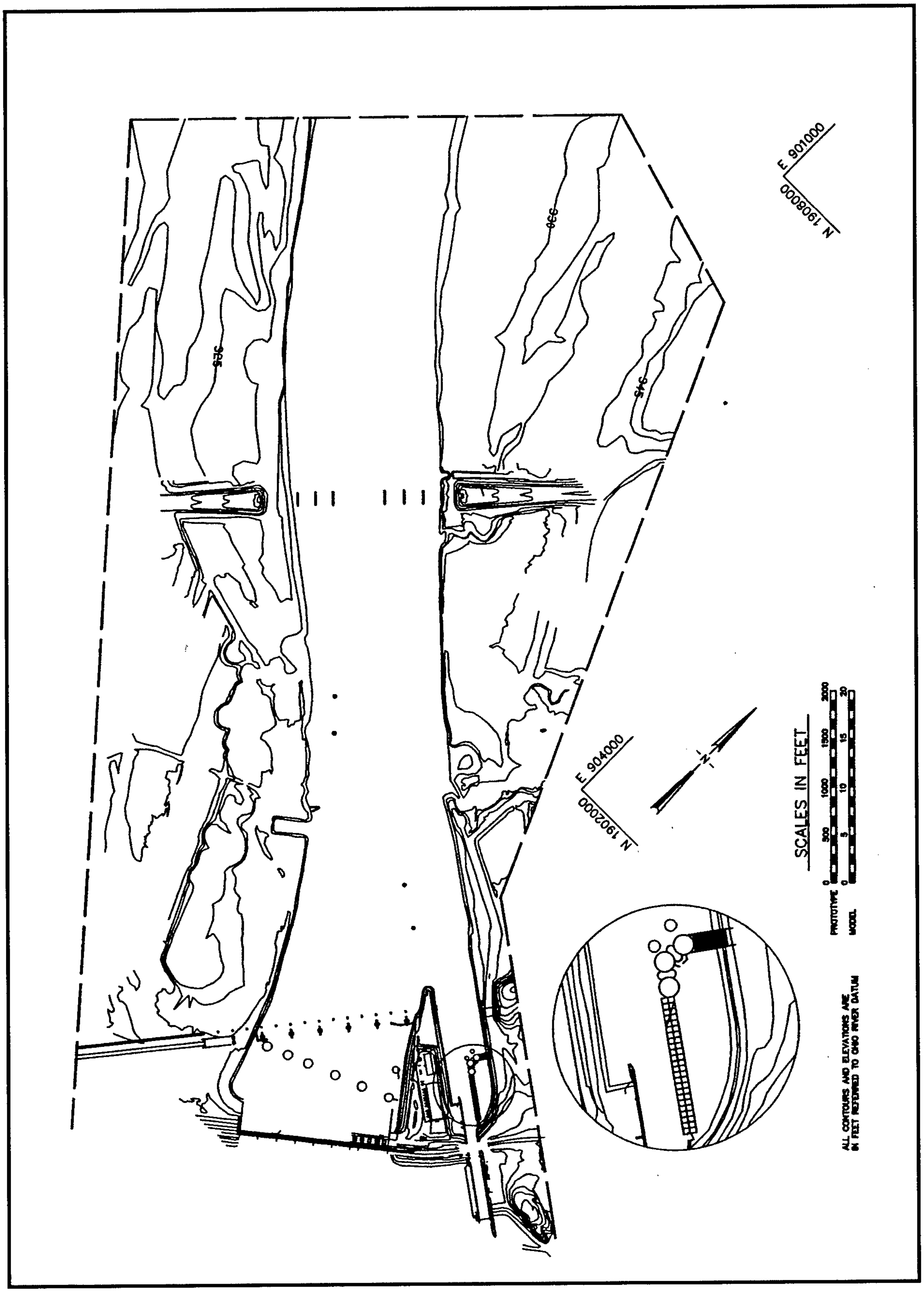


Figure 26. Complete cofferdam conditions

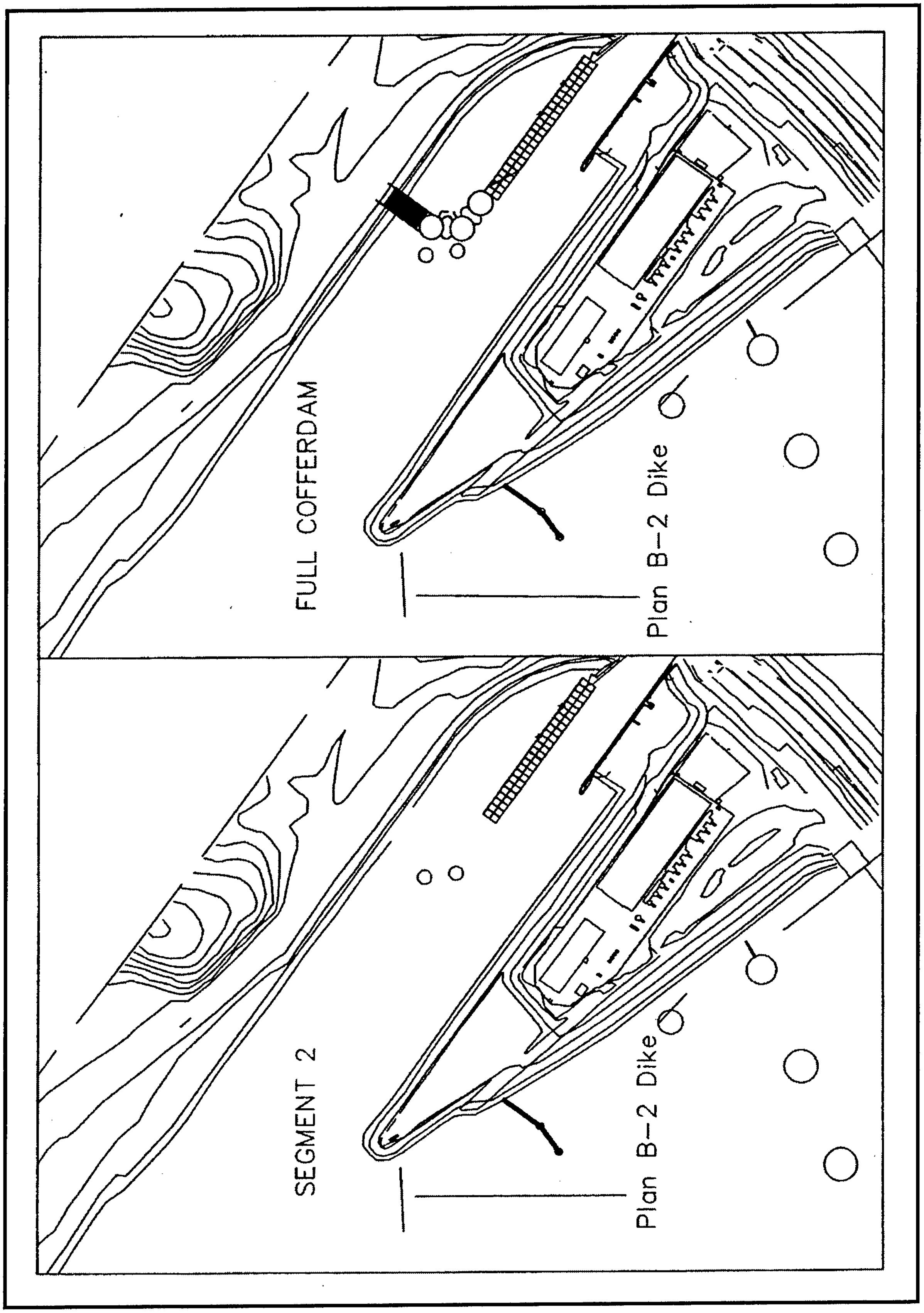


Figure 27. Cofferdam evaluations with Plan B-2 training dike

Tow tracks, downbound. 35,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 137). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned easily into the channel and was brought into alignment with the bridge navigation span. There was no problem getting out of the lock and avoiding guard cells and float-in wall.

79,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 138). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. There was little difficulty in turning out into the channel and getting into alignment for the navigation span. There were no problems getting out of the lock and avoiding guard cells and float-in wall.

100,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 139). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned out into the channel with less ease than the two lower flow conditions, but with no more difficulty than with the existing conditions. No problems were noted getting out of the lock and avoiding guard cells and float-in wall.

Tow tracks, upbound. 35,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from the downstream mooring cell, the tow was steered slightly left (Plate 140). The current caused the tow to slide toward the right bank. The amount of slide was easily regulated by steering right. As the tow passed by the mooring cells, the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be aligned with the island-side guide wall by the time the head of the tow reached the guard cells. A slight angle toward the guide wall was maintained to keep the head on the guide wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the float-in wall. With the floating camels in place (Plate 141), there was no change to the approach made into the lock and avoiding the float-in wall and camels was not difficult.

79,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from the downstream cell, the tow was steered slightly left (Plate 142). The current caused the tow to slide toward the right bank. The amount of slide was easily regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be aligned with the island-side guide wall by the time the head of the tow reached the guard cells. A slight angle toward the guide wall was maintained to keep the head on the wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. The engines were backed briefly to slow the tow moving along the guide wall. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow

moved into the lock. There was no difficulty in avoiding the float-in wall. With the floating camels in place (Plate 143), the approach conditions were the same, and it was not difficult to avoid the float-in wall or the camels.

100,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 144). The current caused the tow to slide toward the right bank, but steering right easily regulated the amount of slide. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be aligned with island-side guide wall by the time the head of the tow reached the guard cells. With the higher tailwater, a slightly straighter approach to the guide wall could be made. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell. The engines were backed briefly to slow the tow moving along the guide wall. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the float-in wall. With the floating camels attached (Plate 145), the approach into the lock was the same and there was no difficulty in avoiding contact with the camels or the float-in wall.

Results, navigation conditions, cofferdam float-in wall segment 2

Current directions and velocities. Current directions and velocities for the 35,000-, 79,000-, and 100,000-cfs flow conditions (Plates 146-148) were not appreciably changed by the installation of the second float-in wall segment as compared to the descriptions given for float-in wall segment 1. For the 155,000-cfs flow (Plate 149) the currents were generally aligned with the bank lines and the eddy in the lock approach was teardrop shaped with the eddy starting at the end of the powerhouse island and coming to the narrow point approximately 1,000 ft downstream along the right bank line. The size and strength of the eddy were similar to that with the base conditions (Plate 16). The velocities at approximately 1,000 ft downstream of the end of the powerhouse island ranged from 4.5 to 5.9 fps.

Tow tracks, downbound. 35,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and angled slightly away from the guide wall and past the guard cells (Plate 150). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned easily into the channel and brought into alignment with the bridge navigation span. There was no problem getting out of the lock and avoiding the guard cells and float-in walls.

79,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 151). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned easily into the channel and brought into alignment with the bridge navigation span. There was no difficulty in getting out of the lock and avoiding the guard cells and float-in walls.

100,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 152). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned out into the channel with less ease than the two lower flow conditions. There was no problem getting out of the lock and avoiding the guard cells and float-in walls.

155,000 cfs - The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 153). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned out into the channel with less ease than the three lower flow conditions. There was no problem getting out of the lock and avoiding the guard cells and float-in walls.

Tow tracks, upbound. 35,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 154). The current caused the tow to slide toward the right bank. The amount of slide was easily regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be angled slightly toward the island. After the head reached the guide wall, a slight angle toward the guide wall was maintained to keep the head on the wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. With the floating camels attached to segment 2 (Plate 155) there was no change in the approach to the lock and there was no difficulty in avoiding contact with the camels or the float-in walls.

79,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 156). The current caused the tow to slide toward the right bank, but the amount of slide was easily regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be aligned with the island-side guide wall by the time the head of the tow reached the guard cells. A slight angle toward the guide wall was maintained to keep the head on the wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. The engines were backed briefly to slow the tow moving along the guide wall. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. With the floating camels installed on wall segment 2 (Plate 157) there was no change to the approach to the lock required and it was not difficult to avoid both the camels and the float-in walls.

100,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 158). The current caused the tow to slide toward the right bank. The amount of the slide was regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be nearly aligned

with the island-side guide wall by the time the head of the tow reached the guard cells. The stern of the tow had to be steered left to overcome the set of the eddy near the end of the island, but this was not difficult to control. With the higher tailwater, a slightly straighter approach to the guide wall could be made. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell. The engines were backed briefly to slow the tow moving along the guide wall. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. With the installation of the floating camels on wall segment 2 (Plate 159), there were no changes made to approach the lock and there was no difficulty in avoiding contact with the camels and the float-in walls.

155,000 cfs - The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 160). The current caused the tow to slide toward the right bank, but the amount of slide was regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed a little to keep the tow from accelerating. The amount of forward engine needed to maintain headway was greater than with the three lower flows. The tow had to be angled slightly toward the island and used the current set from the eddy in the approach to straighten the tow with the lock. The stern of the tow had to be steered left to overcome the set of the eddy near the end of the island, but this was not difficult to control. With the higher tailwater, a somewhat less restrictive approach, due to greater channel width between the guard cell and the powerhouse island, to the guide wall could be made. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell on one of the upbound runs. The engines were backed on one run briefly to slow the tow moving along the guide wall. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. The installation of the floating camels (Plate 161) on wall segment 2 did not require any changes to the approach conditions to the lock and there was no difficulty in avoiding contact with the camels or the float-in wall segments.

Results, navigation conditions, complete cofferdam

Current directions and velocities. The current directions and velocities for the 35,000-, 79,000-, 100,000-, and 155,000-cfs flow conditions (Plates 162-165) were similar to those with cofferdam wall segment 2 and wall segment 1. The only appreciable differences were in the size and position of the eddies in the lock approach. The size and position of an eddy varied slightly over time with any flow condition. The differences that could be noted in the eddies between the plans was more likely a factor of the time at which the data was recorded within the normal random fluctuation of the size and position of the eddies than the plan change. The change in the cofferdam configuration was well up into an area of nearly slack flow or water movement and therefore should be of little influence to the size or strength of the eddy that formed near the end of the powerhouse island. For the 300,000-cfs flow (Plate 166) the currents were generally parallel to the bank line and the currents crossing the downstream approach to the lock had slightly less angle toward the right descending bank line as did the existing conditions. The clockwise eddy near the end of the powerhouse island was

driving a counterclockwise eddy in the lock approach between the right bank and the powerhouse island immediately downstream of the cofferdam. The velocities approximately 1,000 ft downstream of the end of the powerhouse island were from 3.2 to 5.8 cfs. For the 370,000-cfs flow (Plate 167) some flow passed over the left overbank, but most flow was generally parallel to the bank lines and the eddy in the lock approach started about 200 ft downstream of the powerhouse island and extended approximately 1,200 ft downstream toward the right bank line. The velocities approximately 1,000 ft downstream of the end of the powerhouse island were from 2.8 to 5.0 cfs.

Tow tracks, downbound. 35,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall angled slightly away from the guide wall and past the guard cells (Plate 168). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned easily into the channel and brought into alignment with the bridge navigation span. Constriction of the channel cross-sectional area due to the placement of the entire cofferdam appeared to restrict displacement of water as the tow left the lock, causing the tow to be slower leaving the lock and getting past the end of the guide wall and cofferdam than with only the float-in wall segments in place. There was no problem getting out of the lock and avoiding guard cells and the cofferdam.

79,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells, angling the head of the tow slightly away from the island (Plate 169). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned easily into the channel and was brought into alignment with the bridge navigation span. There was no problem getting out of the lock and avoiding the cofferdam. Higher tailwater elevation eased but did not eliminate the problem with water displacement noted with the 35,000-cfs condition.

100,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 170). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The restriction of water displacement noted on the two lower flow conditions was almost completely gone at this tailwater elevation. The tow turned out into the channel with less ease than the two lower flow conditions. There was no problem getting out of the lock and avoiding the guard cells and cofferdam.

155,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 171). After getting at least 100 ft of clearance between the tow and the guard cells, more power was applied to the tow and the tow was steered left. The tow turned out into the channel with less ease than the three lower flow conditions but no greater effort required than with existing conditions. The tow had to be started turning as the head cleared the most downstream mooring cell to get out into the channel and aligned with the navigation span. The tow was aligned to go through the navigation span about one tow length upstream of the bridge. There was no problem getting out of the lock and avoiding guard cells and the cofferdam.

300,000 cfs – The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 172). As tow cleared the guide wall, there was a noticeable set toward the powerhouse island, but it was easy to overcome. The tow had to be turned as soon as it was certain that the head would clear the most downstream mooring cell. The tow slid downstream until reaching the right bank point about two tow lengths downstream of the end of the island. The tow then started moving more out into the channel. The tow could be steered right to straighten up with the bridge span only about 1-½ tow lengths before reaching the bridge and did not get all the angle off the tow until the head was underneath the bridge. The difficulty of the downbound passage was comparable to the existing conditions. There was no problem getting out of the lock and avoiding the guard cells and the cofferdam.

370,000 cfs - The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 173). There was no noticeable set of the tow along the powerhouse island as was noted for the 300,000-cfs flow condition. The tow was driven straight out along the powerhouse island and was turned as soon as possible as the head of the tow passed the most downstream mooring cell. Strong current set made getting out into the channel difficult, but not more so than with the existing conditions. The tow got into alignment to pass through the navigation span approximately one tow length upstream of the I-24 bridge. There was no difficulty in coming out of the lock and avoiding the guard cells and the cofferdam.

Tow tracks, upbound. 35,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from the downstream cell, the tow was steered slightly left (Plate 174). The current caused the tow to slide toward the right bank. The amount of the slide was regulated by steering right. As the tow passed by the mooring cells, the engines had to be slowed to keep from accelerating in the slower current of the eddy. The tow had to be angled slightly toward the island. After the head reached the guide wall, a slight angle toward the guide wall was maintained to keep the head on the wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the cofferdam. Restricted cross-sectional area in the lock approach due to the cofferdam and low tailwater slowed displacement of water as the tow entered, making entry into the lock slow.

79,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 175). The current caused the tow to slide toward the right bank. The amount of slide was easily regulated by steering right. As the tow passed by the mooring cells the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be angled slightly toward island-side guide wall by the time the head of the tow reached the guard cells. A slight angle toward the guide wall was maintained to keep the head on the wall. As the tow glided along the guide wall and toward the lock, the left side of the tow brushed the channelward guard cell slightly. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow

moved into the lock slowly due to water displacement limitations. There was no difficulty in avoiding the cofferdam.

100,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 176). The current caused the tow to slide toward the right bank. The amount of slide was regulated by steering right. As the tow passed by the mooring cells, the engines had to be slowed to keep from accelerating in the slower current in the eddy. Tow had to be nearly aligned with the island-side guide wall by the time the head of the tow reached the guard cells. The stern of the tow had to be steered left to overcome the set of the eddy near the end of the island, but this was not difficult to control. With the higher tailwater, a slightly straighter approach to the guide wall could be made. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the float-in wall.

155,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from the downstream cell, the tow was steered slightly left (Plate 177). The current caused the tow to slide toward the right bank. The amount of slide was not difficult to regulate by steering right. As the tow passed by the mooring cells the engines had to be slowed a little to keep the tow from accelerating. The amount of forward engine needed to maintain headway was greater than with three lower flows. The tow had to be angled slightly toward the island and used the current set from the eddy in the approach to straighten the tow with the lock. The stern of the tow had to be steered left to overcome the set of the eddy near the end of the island, but this was not difficult to control. With the higher tailwater, the channel width available between the powerhouse island and the guard cell was less restrictive and the maneuvering room was increased. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell on one of the upbound runs. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the cofferdam.

300,000 cfs – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 178). The current caused the tow to slide toward the right bank. The amount of slide was easily regulated by steering right. As the tow passed by the mooring cells, the engines had to be slowed a little to keep the tow from accelerating. The current passing through the mooring cells caused the tow to set toward the right bank farther than with the lower flow conditions. As the head of the tow reached the end of the island, the tow could be steered right toward the island. The lateral set toward the island was especially noticeable in the slow upbound approach. The best approaches were made keeping the tow 30 or 40 ft further away from the island than with approaches made with lower flows and having the tow angled slightly toward the guide wall, and letting the current set the tow into alignment to pass the guard cell and into the lock. As the stern of the tow reached the downstream end of the island, the tow had to be steered slightly right to keep the stern off the bank. The head of the tow contacted

the guide wall flush or slightly angled away from the guide wall. Once contact was made, it wasn't difficult to get the tow on the wall and parallel then go up into the lock. The tow made brushing contact with the guard cell as the tow moved into the lock. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the float-in wall, although the tendency for the tow to be pulled toward the island enough that the tow was pointed slightly away from the guide wall and toward the cofferdam was noted. This could be a potential problem if the tow lost power just before the head of the tow got onto the guide wall and into the lock.

370,000 cfs – As with the other flow conditions, the tow was steered more or less directly into the current and toward the downstreammost mooring cell off the end of the powerhouse island (Plate 179). As the head of the tow reached approximately one-half tow length from the mooring cell, the tow could be steered slightly left and the current would then cause the tow to slide toward the right descending bank line. The amount of set was not difficult to control with application of the right rudder. As the tow got alongside the mooring cells the engines had to be slowed to keep from accelerating the tow in the slow currents. With the high tailwater elevation the tow could be steered almost directly into the lock. Flow coming over the end of the powerhouse island tended to cause the tow to be pushed slightly away from the island, but not enough to create any difficulties. The tow could be moved past the guard cells and into the lock with little difficulty. There was no difficulty in avoiding the cofferdam.

Results, navigation conditions, training dike of Plan B-2 and cofferdam float-in wall segment 2

Current directions and velocities. Comparisons of the current directions and velocities recorded with the Plan B-2 dike in place and without the dike (Plates 180 and 164) showed that the eddy that formed in the lock approach had been enlarged and the velocity reduced with the installation of the dike. It could also be noted that the angle that the current passes by the most downstream mooring cell was slightly less with the dike in place.

Tow tracks. 100,000-cfs, downbound – The tow moved out of the lock, past the float-in walls and guard cells, and past the powerhouse island with no difficulty (Plate 181). The turn out into the channel was started as soon as the head could safely pass the most downstream mooring cell. The amount of current set was reduced somewhat in comparison to tows making this same maneuver without the dike being in place. This made it easier to get the tow out into the current and to get aligned with the navigation span of the I-24 bridge. The tow was out into the channel and almost aligned for the navigation span at almost two tow lengths upstream of the bridge.

100,000-cfs, upbound - The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 182). The current caused the tow to slide toward the right bank. The amount of slide was regulated by steering right. The rate of this slide had been reduced somewhat in comparison to conditions without

the Plan B-2 dike in place. As the tow passed by the mooring cells, the engines had to be slowed to keep from accelerating in the slower current in the eddy. The tow had to be nearly aligned with island-side guide wall by the time the head of the tow reached the guard cells. The stern of the tow still had to be steered left to overcome the set of the eddy near the end of the island, but this was not difficult to control and did not require quite as much steering as conditions with the dike in place. As the tow glided along the guide wall and toward the lock, the left side of the tow lightly brushed the channelward guard cell. Once the head of the tow was in the lock, the stern could be steered away from the guard cell and the tow moved into the lock. There was no difficulty in avoiding the float-in wall.

Results, navigation conditions, training dike of Plan B-2 and complete cofferdam

Current directions and velocities. Comparisons of the current directions and velocities recorded with the Plan B-2 dike in place and without the dike (Plates 183 and 166) showed that the eddy that formed in the lock approach had been enlarged and the velocity reduced with the installation of the dike. The reduction of the velocity of the clockwise eddy had reduced the size and strength of the counterclockwise eddy that formed along the east side of the powerhouse island. It could also be noted that the angle that the current passed by the mooring cells was slightly less with the dike in place. The maximum velocity of the current passing between the mooring cells had risen to 5.3 fps with the dike in place as compared with 4.8 fps without the dike.

Tow tracks. 300,000 cfs, downbound - The tow was moved slowly out of the lock along the island-side guide wall and past the guard cells (Plate 184). As the tow cleared the guide wall, there was a slight set toward the powerhouse island, but it was easy to overcome. The tow had to be turned as soon as it was certain that the head would clear the most downstream mooring cell. The tow slid downstream until reaching the right bank point about two tow lengths downstream of the end of the island. The tow then started moving more out into the channel. The tow could be steered right to straighten up with the bridge span only about 1-½ tow lengths before reaching the bridge and did not get all the angle off the tow until the head was underneath the bridge. The downbound transits were comparable in difficulty to the existing conditions, but slightly less difficult as without the training dike. There was no problem getting out of the lock and avoiding guard cells and the cofferdam.

300,000 cfs, upbound – The tow was steered into the current downstream of the island mooring cells and at about one-half tow length from downstream cell, the tow was steered slightly left (Plate 185). The alignment and strength of the current reduced the amount of slide toward the right bank. The amount of slide was regulated by steering right. As the tow passed by the mooring cells, the engines had to be slowed a little to keep from accelerating. The current passing through the mooring cells caused the tow to set toward the right bank, but the amount of set was not difficult to control. As the head of the tow reached the end of the island, the tow could be steered right toward the island. The lateral set toward the island was greatly reduced as compared to conditions without the training dike. The approaches were made with the head of the tow angled toward

the right bank and when the head came inside the alignment with the guard cell, turning the tow left to bring the tow into alignment with the guide wall and lock. As the head of the tow approached the end of the guide wall, the tow was flanked to reduce the approach speed and the flanking rudders were put to the left to keep the stern of the tow off the island and keep the head on the guide wall. Once the head was on the guide wall and the speed was reduced sufficiently, the tow could be brought ahead and steered into the lock. There was no problem avoiding the cofferdam or wall segments.

4 Summary and Conclusions

Limitations of Model Results

Analyses of the results of this investigation were based on a study of the effects of various plans and modifications on current directions and velocities and the effects of the resulting currents on the behavior of the model towboat and tow. In evaluating experimental results, it should be considered that small changes in current directions and velocities were not necessarily changes produced by a modification of the plan since several floats introduced at the same point may follow different paths and move at different velocities because of pulsating current and eddies. Slight variations in the discharge could also be introduced into the model due to the use of a venturi meter that has an accuracy of about plus or minus five percent to measure the discharge. Current directions and velocities shown in the plates were obtained with floats submerged to a depth of a loaded barge (9-ft prototype) and were indicative of the currents that would affect the behavior of tows.

The small scale of the model and the limited number of flow conditions that were evaluated made it difficult to reproduce all of the unique hydraulic characteristics of the prototype or to measure water-surface elevations within an accuracy greater than about +/- 0.1-ft prototype. Current directions and velocities taken from the model were based on steady flows and river stages. The model was of the fixed-bed type and was not designed to reproduce overall sediment movement that might occur in the prototype with the various plans; therefore, changes in channel configuration resulting from scouring and deposition caused by these plans and any resulting changes in current directions and velocities were not evaluated.

It was also determined that the point velocities measured with an ADV meter near the channel bottom were not reliable to be used for any evaluations due to the scale model effects. Point velocities taken higher in the water column, such as those around the bridge piers and near the ends of the proposed training works were sufficiently reliable for analysis.

Summary of Results and Conclusions

The following results and conclusions were developed during the model investigation:

a. *Base conditions.* The most difficult condition evaluated with the base conditions was a tow moving downbound with a 300,000-cfs flow. The strength of the crosscurrent moving across the downstream end of the powerhouse island and through the two mooring cells immediately downstream of the island made getting the tow out into the channel sufficiently enough to get into alignment with the navigation span of the I-24 bridge moderately difficult.

b. *Plan A. Installation of the proposed lock and guide wall.* This plan was installed and preliminarily evaluated while the final designs for the proposed highway and railroad bridge piers were being developed. This configuration in which the proposed lock would be constructed and in operation prior to construction of the highway and railroad bridges will not exist in the prototype; therefore, this plan was not documented for this report.

c. *Plan B. Installation of the proposed lock and guide wall and the proposed highway and railroad bridge piers.* Navigation conditions for downbound tows were generally good with no significant difficulty in getting the tow off the guide wall and getting the tow out into the channel to align for passage through the I-24 bridge. The navigation conditions for upbound tows generally were not difficult, except for the tendencies of the eddy that formed in the lock approach immediately at the downstream end of the proposed guide wall to keep the stern of the tow from getting onto the wall as the tow moved upstream along the guide wall, especially with the 300,000-cfs flow.

d. *Plan B-1. Single training work to reduce eddy size and strength in lower lock approach.* Navigation conditions for downbound tows were generally good for all flow conditions. The size and strength of the eddy that formed in the lower lock approach was reduced and navigation conditions improved for upbound tows. This plan was examined by representatives of the towing industries and they suggested that additional reduction to the size and strength of the eddy would be desirable for upbound tow traffic.

e. *Plan B-2. Single training work after installation of proposed fishing jetties.* Navigation conditions for downbound tows were generally good. The size and strength of the eddy that formed in the lower lock approach was reduced, especially at the 300,000-cfs flow condition. This allowed upbound tows to get onto the guide wall and stay on the wall with less difficulty than with either the Plan B or Plan B-1 conditions.

f. *Plan C. Installation of training works to reduce recirculation in the spillway.* The current directions and velocities indicated that the training structures for Plan C would reduce the size and strength of the large spillway eddy on flows of 100,000 cfs and less. The Plan C structures had a minimal benefit on the spillway eddy at 155,000 cfs and had no

apparent effects on the 300,000- and 370,000-cfs flow conditions. There were some changes noted in the size and strength of the eddy that formed in the downstream lock approach, but these changes were small. The downbound tow tracks indicated that navigation conditions would be similar to or slightly improved over those with Plan B-2. The upbound tow tracks indicated that navigation conditions would be similar to those of Plan B-2. It was noted that the current set, especially as the upbound tow neared the right descending bank line approximately 1,000 ft downstream from the lower end of the guide wall was less than experienced with the Plan B-2 conditions. This reduction of current set with Plan C made downbound tows easier to get out into the channel, even though downbound tow passages with Plan B-2 were not difficult. The slight changes to the eddy that formed in the downstream lock approach with Plan C versus Plan B-2 had no appreciable effects on the upbound approaches.

g. *Water-surface profiles.* The water-surface elevations recorded during evaluation of each plan and flow condition indicated the largest change in water-surface elevation of 0.3 ft in the spillway adjacent to the training works installed for Plan C. Most other plans had 0.2 ft or less of surface elevation change as compared to the base conditions.

h. *Left bank fishing jetties.* The revised plan of installing two longer and more widely spaced fishing jetties rather than three short and more closely spaced jetties had no appreciable effect on navigation conditions. Upbound tows approaching and leaving from the left bank mooring cells were not adversely impacted by the proposed jetties.

i. *Railroad truss float-in.* Maneuvering the truss/barge configuration out of the enlarged left bank boat basin, turning to face upstream, avoiding the high tension powerlines, and going upstream past the mooring cells and into position to be placed on the piers was performed with only slight to moderate difficulty with flow conditions a and b. The stronger currents for flow conditions c and d required much more difficult maneuvering. The maneuvers made using lines to hold the truss/barge configuration in place were more difficult to perform than those which were attempted using a piling at the downstream channelward edge of the boat basin to hold the configuration against the current set and allow it to pivot, although attempts using lines and the piling were successful.

j. *Powerhouse island pier impacts.* Impacts on the highway and railroad piers were recorded on seven of the 50 runs made with Plan B-2 and nine of the 50 runs with Plan C with upbound tows losing all maneuvering capability from 200 to 600 ft downstream of the lower end of the guide wall with the 300,000-cfs flow condition. Only at tailwater of approximately 325.0 or greater was there sufficient water depth for the full-loaded tow to reach the piers.

k. *Velocities measured in water column for mussel bed impacts.* Examination of velocities collected in the water column near the bed of the model indicated that the velocities were not consistently reliable enough for meaningful comparisons to use in evaluation of possible impacts to mussel beds.

l. *Cofferdam float-in wall segment 1.* Navigation conditions for downbound traffic were not difficult and there were no tendencies for the tow to threaten the float-in wall. Upbound traffic into the lock approach and past the guard cells and the float-in wall were not difficult and there was no threat to hit the float-in wall. The use of the floating camels did not increase the difficulty of the upbound tow runs.

m. *Cofferdam float-in wall segment 2.* Navigation conditions for downbound and upbound tows were not any more difficult than with the single wall in place. The use of the floating camels on segment 2 of the wall did not increase the difficulty of the upbound tow runs. Avoiding contact with the float-in walls, with or without the camels was not difficult.

n. *Full cofferdam.* Navigation conditions for downbound tows were not difficult for any flow condition. Navigation conditions for upbound tows were not difficult for any flow condition; however, the eddy near the end of the powerhouse island with the 300,000-cfs flow tended to push the stern of the tow toward the island and had the tow angled slightly toward the cofferdam as the tow made contact with the guide wall. Once on the wall, the tow could be brought into alignment to enter the lock and did not strike the cofferdam.

o. *Plan B-2 with segment 2 of cofferdam, 100,000-cfs flow.* Navigation conditions with downbound and upbound tows were somewhat improved by the installation of the Plan B-2 dike.

p. *Plan B-2 with full cofferdam, 300,000-cfs flow.* Navigation conditions for the downbound tows were slightly improved by the Plan B-2 dike. Navigation conditions for the upbound tows were significantly improved in that the set of the stern near the end of the powerhouse island was almost totally absent with the Plan B-2 dike in place and the approach onto the guide wall was with the tow angled slightly toward the guide wall.

All the stated objectives as outlined in Chapter 1 of this report were met. Of the plans evaluated, Plan B-2 or Plan C would provide acceptable navigation conditions. During the construction phases there were no excessively difficult navigation conditions noted except for upbound approaches to the existing 600-ft lock with a 300,000-cfs flow condition. Navigation conditions at this flow were improved by the installation of the training work developed during Plan B-2. The model also provided velocity information that would be used to help design scour protection for the proposed highway and railroad bridge piers and to design the stone sizing and gradation for the training works developed during Plan B-2 and C. Additionally, the model was used to provide recommendations for moving the float-in railroad truss from the left bank boat basin to the downstream lock approach and confirmed that the proposed fishing jetties would not adversely impact navigation.

Table 1
Water Surface Elevations, Kentucky Lock and Dam Model

Gage No.	Base	Plan B	Plan B-2	Plan C
35,000 cfs 359.0 HW 300.0 TW				
1	359.0	359.0	359.0	359.0
2L	300.1	300.1	300.1	300.1
2R	300.2	300.1	300.1	300.1
3L	300.1	300.2	300.1	300.2
3R	300.1	300.2	300.2	300.1
4*	300.0	300.1	300.1	300.1
5L	300.1	300.1	300.1	300.0
5R	300.1	300.1	300.0	300.0
6	300.1	300.0	300.1	300.0
7	300.1	300.0	300.0	300.0
8	299.9	299.8	299.8	299.8
9**	299.7	299.7	299.7	299.7
79,000 cfs 359.0 HW 303.6 TW				
1	359.0	359.0	359.0	359.0
2L	303.5	303.4	303.5	303.6
2R	303.4	303.4	303.5	303.5
3L	303.5	303.5	303.6	303.7
3R	303.6	303.6	303.7	303.7
4*	303.6	303.4	303.5	303.5
5L	303.6	303.6	303.6	303.6
5R	303.4	303.4	303.4	303.4
6	303.4	303.4	303.5	303.4
7	303.2	303.1	303.3	303.3
8	302.9	302.7	302.9	302.9
9**	302.5	302.5	302.5	302.5
100,000 cfs 358.0 HW 306.3 TW				
1	358.0	358.0	358.0	358.0
2L	306.2	306.3	306.2	306.4
2R	306.4	306.4	306.3	306.7
3L	306.2	306.4	306.2	306.4
3R	306.3	306.5	306.3	306.6
4*	306.3	306.3	306.2	306.3
5L	306.2	306.5	306.3	306.2
5R	306.2	306.3	306.1	306.2
6	306.1	306.2	306.1	306.2
7	306.0	306.1	305.9	306.1
8	305.7	305.7	305.5	305.7
9**	305.4	305.4	305.4	305.4

(Continued)

* Water surface controlled at this gage during base conditions, establishing tailwater elevation at Gage 9.
** Water surface controlled at this gage during plan conditions to allow water surface in model to vary with plan condition installed.

Table 1 (Concluded)				
Gage No.	Base	Plan B	Plan B-2	Plan C
155,000 cfs 359.0 HW 316.0 TW				
1	359.0	359.0	359.0	359.0
2L	316.1	315.9	315.9	316.0
2R	316.2	316.2	316.1	316.3
3L	316.1	316.2	316.0	316.2
3R	316.1	316.2	316.1	316.3
4*	316.0	315.9	315.9	316.0
5L	315.9	315.9	315.8	315.9
5R	315.9	315.9	315.8	315.9
6	315.8	315.8	315.8	315.8
7	315.7	315.7	315.7	315.7
8	315.5	315.4	315.5	315.5
9**	315.4	315.4	315.4	315.4
300,000 cfs 362.5 HW 328.0 TW				
1	362.5	362.5	362.5	362.5
2L	328.2	328.4	328.0	328.3
2R	328.2	328.4	328.1	328.4
3L	328.3	328.4	328.0	328.3
3R	328.2	328.3	328.2	328.4
4*	328.0	328.2	328.0	328.1
5L	328.0	328.1	327.8	328.0
5R	328.0	328.1	327.8	328.0
6	327.9	328.1	327.8	328.0
7	327.7	327.9	327.6	327.8
8	327.5	327.6	327.3	327.5
9**	327.3	327.3	327.3	327.3
370,000 cfs 368.3 HW 344.0 TW				
1	368.3	368.3	368.3	368.3
2L	344.1	344.0	344.1	344.1
2R	344.0	344.0	344.1	344.1
3L	344.1	344.0	344.1	344.0
3R	344.1	344.1	344.1	344.1
4*	344.0	344.0	344.1	344.0
5L	344.0	344.0	344.0	344.0
5R	343.9	344.0	344.0	344.0
6	343.9	343.9	344.0	344.0
7	343.8	343.9	343.9	343.9
8	343.7	343.6	343.7	343.7
9**	343.6	343.6	343.6	343.6

Table 2
Pier Impacts, 600-ft Release, Plan B-2 (370,000 cfs, 344.0 TW)

All runs are upbound with 15-barge tow drafting 9 ft with power and steering shut off as head of tow reaches specified distance from upstream end of proposed guide wall
Note: All distances are in feet, angles in degrees with positive value indicating tow pointing away from proposed guide wall, speeds in feet per second (fps)

Run No.	Dist. To GD Wall	Dist. To Baseline	Tow Angle	Tow Speed	Impact Pt on Tow		Object Impacted	Impact Angle	Impact Speed	Comments
					Front	R Side				
1	600	240	6.4	3.4	60		ISL	27.6	0.2	Grounded 30' DS of RR(DS)
2	600	120	10.5	3.2	45		BN	18.8	0.2	Hit BN, rotated and stopped 30' from RR(DS) at 850' along tow
3	600	170	15.3	3.8			-	-	-	Stopped in approach to old lock 150' from piers
4	600	250	13.0	3.4		10	HWY	11.2	-0.3	Tow stopped adjacent to piers, stopped then backed and rotated into HWY
5	600	230	14.9	4.1			-	-	-	Stopped with head 200 ft US of end of new GW in center of approaches
6	600	210	12.8	3.4	0		RR(DS)	19.7	0.5	
7	600	250	13.6	3.4			-	-	-	Stopped 200' DS of end of ISL
8	600	235	11.2	3.0			-	-	-	Stopped with head 80' US of HWY, 75' away from piers
9	600	260	7.1	4.5	60		ISL	24.2	0.6	Grounded on ISL 75' DS of RR(DS)
10	600	235	14.9	4.0	75		ISL	16.4	0.3	Grounded on ISL 150' DS of RR(DS)
11	600	200	14.7	2.9			-	-	-	Stopped with head 50' US of end of new GW, 75' off wall
12	600	230	12.4	3.6			-	-	-	Stopped with head even with end of new GW, 250' off wall
13	600	215	14.1	4.0	75		ISL	20.0	0.6	Grounded on ISL 100' DS of RR(DS)
14	600	170	8.0	4.5		790	RR(DS)	-4.8	<0.1	Head misses HWY by 20', rotates and hits RR(DS)
15	600	170	10.7	4.3		575	RR(DS)	1.9	<0.1	Head misses HWY by 25', rotates and hits RR(DS)
16	600	190	11.7	4.9	30		ISL	24.0	0.4	Grounded on ISL 50' DS of RR(DS)
17	600	170	14.8	4.1			-	-	-	Head misses RR(DS) by 40', stops with head 150' US of HWY
18	600	180	13.3	3.7	40		ISL	27.8	0.5	Grounded on ISL 75' DS of RR(DS)
19	600	180	10.2	4.3			-	-	-	Head misses HWY by 50', drifts into old lock approach
20	600	160	10.7	3.1	10		BN	18.3	0.2	Head misses HWY by 75', hit BN, rotated and stopped 80' off RR(DS) at 800' along tow
21	600	160	11.7	4.3	30		ISL	24.3	1.0	Grounded on ISL 40' DS of RR(DS)
22	600	165	12.2	4.4			-	-	-	Head misses HWY by 30' then drifts down behind old GW
23	600	95	8.2	3.9			-	-	-	Tow goes into old lock approach, 150' off piers
24	600	190	9.4	4.9			-	-	-	Head misses HWY by 35' then goes in behind old GW
25	600	215	13.5	3.9	40		ISL	18.2	0.9	Grounded on ISL 80' DS of RR(DS)

Distance to guide wall - Distance from head of tow to downstream end of proposed guide wall when power shut down
Distance to baseline - Distance from left edge of tow to extension of alignment of face of proposed guide wall
Tow angle - Angle of tow at power shutdown, relative to proposed guide wall
Tow speed - Speed of tow at power shutdown
Impact point of tow - Distance from right front corner of tow along head and right side of contact with object
Object impacted - Which object(s) received impact
Impact speed - Speed of tow at impact with object
Impact angle - Angle of tow at impact with object, relative to proposed guide wall
RR(US) - Railroad pier, upstream
RR(DS) - Railroad pier, downstream
HWY - Highway pier
ISL - Powerhouse island
DS - Downstream
US - Upstream
BN - Bullnose separating locks
GW - Guide wall

Table 3
Pier Impacts, 200-ft Release, Plan B-2 (370,000 cfs, 344.0 TW)

All runs are upbound with 15-barge tow drafting 9 ft with power and steering shut off as head of tow reaches specified distance from upstream end of proposed guide wall
Note: All distances are in feet, angles in degrees with positive value indicating tow pointing away from proposed guide wall, speeds in feet per second (fps)

Run No.	Dist. To GD Wall	Dist. To Baseline	Tow Angle	Tow Speed	Impact Pt on Tow		Object Impacted	Impact Angle	Impact Speed	Comments
					Front	R Side				
1	200	280	9.4	4.0	0		RR(DS)	17.4	1.6	
2	200	255	6.9	4.3	32		OLD GW	5.4	0.3	Drifted into old lock approach and hit old GW
3	200	270	8.4	3.9	90		BN	-0.2	0.4	Hit BN and stopped 150' away from piers
4	200	300	11.0	4.7	20		RR(DS)	20.5	1.2	
5	200	285	11.2	4.0	5		RR(DS)	18.5	0.9	
6	200	280	2.1	3.4	25		BN	-17.6	0.2	Hit BN, rotates and stops 40' from piers
7	200	270	8.0	4.0	50	940	OLD GW RR(DS)	2.1 -10.2	0.4 <0.1	Hit old GW, rotates and hits RR(DS)
8	200	255	5.9	4.2	95		OLD GW	8.3	0.3	Hits old GW, rotates and stops 10' from HWY at 920' along tow
9	200	295	4.2	3.6	0		RR(DS)	19.9	1.3	
10	200	290	4.3	3.7	100		BN	-14.7	0.2	Hit BN, rotates and stops 15' from RR(DS) at 840' along tow
11	200	301	8.4	3.7	25		BN	-10.2	0.2	Hit BN, rotates and stops 120' from RR(DS) at 810' along tow
12	200	280	7.4	4.8	35		OLD GW	0.6	0.3	Hit old GW, rotates and stops 75' from RR(DS) at 800' along tow
13	200	325	5.4	3.7	55	975	OLD GW RR(DS)	-3.5 1.9	0.2 <0.1	Hit old GW, rotates and hits RR(DS)
14	200	285	9.5	3.7	30		OLD GW	2.9	0.2	Hit old GW, rotates and stops 120' from piers
15	200	300	7.4	3.6	105		BN	-2.2	0.7	Missed HWY by 40', hit BN along taper, glides into old lock
16	200	345	10.9	4.6	20		ISL	17.1	1.7	Grounded on ISL 60' DS of RR(DS)
17	200	280	8.2	3.2	5		OLD GW	-2.5	0.3	Hit old GW, rotates and stops 60' from RR(DS) at 950' along tow
18	200	300	5.7	3.7	0		HWY	29.3	0.8	Hits outer edge of HWY pier
19	200	275	10.8	3.8			-	-	-	Misses HWY by 25', rotates and stops 75' from RR(DS) at 500' along tow
20	200	315	5.9	3.7			-	-	-	Misses HWY by 5', rotates and goes into old lock approach, stops with stern of tow 75' away from piers
21	200	285	7.9	3.1	0		HWY	16.3	0.9	
22	200	280	8.2	3.8	0		BN	-6.6	0.6	Misses HWY by 10', hit BN, rotates and stops 10' from RR(DS) at 960' along tow
23	200	295	7.7	4.3		960	OLD GW RR(DS)	1.2 -4.1	0.7 <0.1	Misses HWY by 40', hit old GW, rotates and hits RR(DS)
24	200	270	9.9	4.1		895	RR(DS)	-6.6	<0.1	Misses HWY by 30',rotates and hit RR(DS)
25	200	265	7.9	2.9	85		BN	-7.2	0.8	Hit BN, rotates and stops 5' from RR(DS) at 840' along tow

Distance to guide wall - Distance from head of tow to downstream end of proposed guide wall when power shut down
Distance to baseline - Distance from left edge of tow to extension of alignment of face of proposed guide wall
Tow angle - Angle of tow at power shutdown, relative to proposed guide wall
Tow speed - Speed of tow at power shutdown
Impact point of tow - Distance from right front corner of tow along head and right side of contact with object
Object impacted - Which object(s) received impact
Impact speed - Speed of tow at impact with object
Impact angle - Angle of tow at impact with object, relative to proposed guide wall
RR(US) - Railroad pier, upstream
RR(DS) - Railroad pier, downstream
HWY - Highway pier
ISL - Powerhouse island
DS - Downstream
US - Upstream
BN - Bullnose separating locks
GW - Guide wall

Table 4
Pier Impacts, 600-ft Release, Plan C (370,000 cfs, 344.0 TW)

All runs are upbound with 15-barge tow drafting 9 ft with power and steering shut off as head of tow reaches specified distance from upstream end of proposed guide wall
Note: All distances are in feet, angles in degrees with positive value indicating tow pointing away from proposed guide wall, speeds in feet per second (fps)

Run No.	Dist. To GD Wall	Dist. To Baseline	Tow Angle	Tow Speed	Impact Pt on Tow		Object Impacted	Impact Angle	Impact Speed	Comments
					Front	R Side				
1	600	175	8.2	4.0	5		HWY	14.4	0.7	
2	600	180	11.2	4.0	60		ISL	17.5	0.2	Grounded on ISL 80' DS of RR(DS)
3	600	150	11.4	4.6	30		RR(DS)	23.7	1.0	
4	600	135	11.9	4.0	45		ISL	21.1	0.8	Grounded on ISL 75' DS of RR(DS)
5	600	235	10.4	3.6				-	-	Tow stopped with head just off end of ISL
6	600	130	11.3	3.1	60		ISL	20.0	0.8	Grounded on ISL 90' DS of RR(DS)
7	600	185	4.9	4.5	10		BN	-17.6		Hit BN, rotates and stops 40' from RR(DS) at 750' along tow
8	600	150	4.7	3.9	0		BN	-3.9	0.7	Hit BN along taper toward old lock, glides into old lock approach 100' off piers
9	600	130	5.5	3.3	75		ISL	38.4	0.5	Grounded on ISL 60' DS of RR(DS)
10	600	200	8.5	4.8	20		RR(DS)	25.6	0.9	
11	600	175	5.9	3.4		900	ISL	-16.3	<0.1	Right stern grounds on ISL 70' DS of RR (DS), RR(DS) is 30' from tow @ 800' along the side
12	600	245	13.9	4.3				-	-	Tow stops with head just off end of ISL
13	600	180	12.0	2.8				-	-	Tow stops with head even with end of new GW, parallel and about 50' off new GW
14	600	155	6.3	4.3		860	RR(DS)	-5.7	<0.1	Head of tow misses HWY by 15', rotates and hits RR(DS)
15	600	155	7.5	3.8	10	30	HWY RR(US)	17.6 17.6	0.7 <0.1	Hits HWY first, then RR (US)
16	600	170	8.0	4.1		875	RR(DS)	-4.2	<0.1	Moves into old lock approach, rotates and hits RR(DS)
17	600	165	2.7	3.6		740	RR(DS)	-7.1	<0.1	Moves into old lock approach, rotates and hits RR(DS)
18	600	180	7.2	4.5	85		BN	-0.5	0.3	Head of tow misses HWY by 10', hits BN and stops
19	600	220	0.5	4.2	80		BN	-5.7	0.5	Hit BN and stopped
20	600	150	7.9	3.9				-	-	Stopped with head almost even with BN, aligned in old lock approach
21	600	190	6.9	4.1	10		RR(DS)	25.8	1.1	
22	600	165	5.9	4.4	20		OLD GW	-1.0	0.2	Hit end of old GW and stopped
23	600	160	5.6	2.9	60		ISL	25.3	0.5	Grounded on ISL 40' DS of RR(DS)
24	600	230	9.2	3.6	50		ISL	25.3	0.2	Grounded on ISL 30' DS of RR(DS)
25	600	185	4.9	3.7				-	-	Tow stops with midlength to piers, 100' off piers

Distance to guide wall - Distance from head of tow to downstream end of proposed guide wall when power shut down
Distance to baseline - Distance from left edge of tow to extension of alignment of face of proposed guide wall
Tow angle - Angle of tow at power shutdown, relative to proposed guide wall
Tow speed - Speed of tow at power shutdown
Impact point of tow - Distance from right front corner of tow along head and right side of contact with object
Object impacted - Which object(s) received impact
Impact speed - Speed of tow at impact with object
Impact angle - Angle of tow at impact with object, relative to proposed guide wall
RR(US) - Railroad pier, upstream
RR(DS) - Railroad pier, downstream
HWY - Highway pier
ISL - Powerhouse island
DS - Downstream
US - Upstream
BN - Bullnose separating locks
GW - Guide wall

Table 5
Pier Impacts, 200-ft Release, Plan C (370,000 cfs, 344.0 TW)

All runs are upbound with 15-barge tow drafting 9 ft with power and steering shut off as head of tow reaches specified distance from upstream end of proposed guide wall
Note: All distances are in feet, angles in degrees with positive value indicating tow pointing away from proposed guide wall, speeds in feet per second (fps)

Run No.	Dist. To GD Wall	Dist. To Baseline	Tow Angle	Tow Speed	Impact Pt on Tow		Object Impacted	Impact Angle	Impact Speed	Comments
					Front	R Side				
1	200	240	12.0	3.1	0		ISL	19.5	1.0	Missed HWY by 20', grounded 120' US of HWY
2	200	235	10.2	3.2	10 0	 940	OLD GW RR(DS)	2.8 -1.2	0.5 <0.1	Hit old GW, rotates, and hits RR(DS)
3	200	285	12.9	2.9	15		RR(DS)	17.8	1.0	
4	200	310	10.8	2.7	45		ISL	21.7	0.7	Grounded on ISL 15' DS of RR (DS)
5	200	265	12.3	2.8	8		RR(DS)	23.6	0.8	
6	200	265	11.5	2.7	0		BN	-9.0	0.5	Hit taper of BN, rotates and stops 10 ' from RR(DS) at 880' along tow
7	200	295	2.1	3.2	50		BN	-3.6	0.6	Hit BN, stopped 75' away from piers at 800' along tow
8	200	280	6.0	3.1	45		BN	-2.7	0.8	Hit BN, stopped 150' away from piers at 800' along tow
9	200	280	7.5	2.6	-			-		Misses HWY by 30', glides into old lock approach, stops 60' away from piers
10	200	265	6.5	3.0	0		BN	-2.9	0.7	Hit BN near mid taper, stops 150' from piers with stem opposite piers
11	200	285	10.7	2.8	0		ISL	25.0	0.6	Missed HWY by 10', strikes ISL 100' US of HWY, stops
12	200	255	9.3	4.0	-			-		Drifted into old lock approach, never closer than 100' to piers
13	200	305	15.0	2.5	30		ISL	24.7	0.6	Grounded on ISL 50' DS of RR(DS)
14	200	260	10.5	2.9	5		OLD GW	4.5	0.3	Hit end of old GW, stopped 150' away from piers
15	200	325	3.4	3.0		720	RR(DS)	-10.4	<0.1	Missed HWY by 50', rotates and strikes RR(DS)
16	200	240	17.1	3.4	30		RR(DS)	22.0	1.3	
17	200	285	12.9	3.2	30		ISL	30.1	1.0	Grounded on ISL 50' DS of RR(DS)
18	200	275	10.4	3.1	-		ISL	21.4	0.9	Missed HWY by 5', grounded on ISL 100' US of HWY
19	200	270	10.0	3.4	0	 960	OLD GW RR(US)	5.4 -3.5	0.7 <0.1	Missed HWY by 40', hit end of old GW, rotated and strikes RR(US)
20	200	295	11.2	2.7	0		BN	-12.8	0.4	Missed HWY by 25', hit BN near mid taper, stops 5' from RR(DS) at 850' along tow
21	200	285	1.4	2.8	10 5		New GW	-17.4	0.4	Hit new GW 100' DS from lock, rotates and stops 75' from RR(DS)
22	200	285	9.7	3.5	10 5		BN	2.8	1.0	Touches taper of BN, glides into old lock approach 100' away from piers
23	200	260	13.4	3.4	60		ISL	27.8	1.6	Grounded on ISL 75' from RR(DS)
24	200	265	12.6	3.3	10 5 5		BN OLD GW	-2.4 -1.5	0.9 0.1	Touches BN 20' from where it attaches to lock, then hits old GW, then stops 80' from piers at 900' along tow
25	200	250	14.7	3.2	0		RR(DS)	17.4	1.5	

Distance to guide wall - Distance from head of tow to downstream end of proposed guide wall when power shut down
Distance to baseline - Distance from left edge of tow to extension of alignment of face of proposed guide wall
Tow angle - Angle of tow at power shutdown, relative to proposed guide wall
Tow speed - Speed of tow at power shutdown
Impact point of tow - Distance from right front corner of tow along head and right side of contact with object
Object impacted - Which object(s) received impact
Impact speed - Speed of tow at impact with object
Impact angle - Angle of tow at impact with object, relative to proposed guide wall

RR(US) - Railroad pier, upstream
RR(DS) - Railroad pier, downstream
HWY - Highway pier
ISL - Powerhouse island
DS - Downstream
US - Upstream
BN - Bullnose separating locks
GW - Guide wall

Table 6
Spillway Velocities, Plan B-2, Kentucky Lock and Dam Model

Gate Bay	Four-tenths Velocity ft/sec	Six-tenths Velocity ft/sec
1	5.8	5.2
2	3.4	2.8
3	1.8	1.2
5	1.4	0.5
7	-0.3	-0.8
9	-1.3	-1.7
11	-1.0	-1.3
13	0.4	1.0
14	2.2	2.3
15	4.6	4.5
16	5.8	5.4
17	6.4	5.4
18	5.9	4.8
19	5.3	4.4
20	4.7	3.9
21	4.7	4.2
22	4.7	3.4
23	4.4	3.0
24	5.7	4.9

Note: Velocities taken 500 ft downstream from axis of dam aligned with center of each open gate bay 300,000-cfs flow condition, velocities taken at four and six-tenths depths from water surface.

Table 7
Spillway Velocities, Plan C, Kentucky Lock and Dam Model

Gate Bay	Four- tenths Velocity ft/sec	Six-tenths Velocity ft/sec
1	5.5	5.0
2	3.2	2.0
3	1.2	0.6
5	1.7	1.3
7	1.1	1.0
9	-1.6	-1.6
11	-1.2	-1.3
13	0.8	1.1
14	2.6	2.7
15	4.8	4.6
16	5.9	5.2
17	6.6	5.6
18	6.3	5.0
19	5.9	5.4
20	5.3	4.7
21	5.3	4.8
22	4.6	3.4
23	4.5	3.4
24	5.2	4.9

Note: Velocities taken 500 ft downstream from axis of dam aligned with center of each open gate bay 300,000-cfs flow condition, velocities taken at four and six-tenths depths from water surface.

Table 8
Velocities at Proposed Highway Bridge Piers, Kentucky Lock and Dam Model

Depth	Pier 2	Piers 3	Pier 4	Pier 5	Pier 6	Pier 7
35,000 cfs						
2/10	-	-0.7	1.2	2.2	3.3	-
6/10	-	-0.7	1.2	2.0	3.1	-
8/10	-0.4	-0.6	0.7	1.7	2.8	-
79,000 cfs						
2/10	-	-1.6	2.3	3.6	5.6	-
6/10	-2.2	-1.5	2.2	3.6	5.5	-
8/10	-	-1.7	2.1	3.5	5.3	-
100,000 cfs						
2/10	-	-1.5	3.9	5.0	5.2	-
6/10	-1.3	-1.3	3.9	4.7	5.3	0.1
8/10	-	-1.2	3.7	4.3	5.0	-
155,000 cfs						
2/10	1.0	1.1	1.8	3.8	3.7	-
6/10	0.7	1.1	1.7	4.0	4.1	2.0
8/10	0.9	0.9	1.8	4.0	4.2	0.7
300,000 cfs						
2/10	6.6	5.0	3.5	3.0	3.9	0.7
6/10	6.9	4.5	3.3	2.7	3.4	4.2
8/10	7.0	4.5	2.9	2.3	3.3	3.2
370,000 cfs						
2/10	6.9	2.6	1.2	3.6	4.2	1.9
6/10	3.6	2.0	1.0	2.8	3.3	1.7
8/10	6.1	1.8	0.9	2.5	3.2	1.6

Note: Velocities taken approximately 20 ft upstream of piers with Plan B-2 installed, fps.

Table 9
Velocities at Proposed Railroad Bridge Piers, Kentucky Lock and Dam Model

Depth	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	Pier 12	Pier 13	Pier 14
35,000 cfs											
2/10	-	-0.6	-0.5	0.6	1.6	1.4	2.3	3.7	-	-	-
6/10	0.1	-0.7	-0.4	0.7	1.1	1.4	1.9	3.5	2.4	2.0	-
8/10	-	-0.7	-0.4	0.5	1.3	1.3	2.0	2.8	2.5	-	-
79,000 cfs											
2/10	-	-2.4	-1.0	1.3	3.6	4.1	4.0	5.7	2.9	-	-
6/10	0.1	-2.6	-1.1	1.4	3.7	4.3	3.8	5.5	3.5	3.4	-
8/10	-	-2.5	-0.9	1.2	3.2	3.8	3.9	5.3	4.1	-	-
100,000 cfs											
2/10	-	-2.0	-1.9	2.7	4.7	5.3	4.4	4.9	2.4	-	-
6/10	-0.7	-2.7	-1.9	2.7	4.8	5.1	4.5	5.1	3.1	3.3	-
8/10	-	-2.8	-1.6	2.5	4.8	4.8	4.4	5.0	3.6	3.3	-
155,000 cfs											
2/10	-	1.0	0.8	1.5	1.3	2.6	1.8	4.3	2.3	3.1	-
6/10	-	0.6	1.2	1.7	2.0	2.7	3.7	4.5	3.1	3.1	-
8/10	-0.1	0.3	1.2	1.7	2.0	2.8	3.9	4.7	3.5	3.2	-
300,000 cfs											
2/10	6.0	5.0	5.1	4.7	4.3	2.9	1.8	4.7	3.8	4.1	2.2
6/10	5.7	4.9	5.0	4.4	4.4	2.7	2.4	4.4	3.9	3.4	3.0
8/10	3.9	4.5	5.2	4.6	4.5	2.8	2.7	4.4	3.6	3.2	3.3
370,000 cfs											
2/10	6.2	4.8	3.0	2.1	1.1	2.3	2.1	4.9	4.5	3.9	2.7
6/10	5.8	4.3	2.9	1.6	0.9	1.8	2.4	3.8	4.1	3.1	2.1
8/10	4.7	4.8	2.9	1.6	1.1	2.0	2.1	3.9	3.5	2.5	2.1

Note: Velocities taken approximately 20 ft upstream of piers with Plan B-2 installed, fps.

Table 10 Velocities at Proposed Highway Bridge Piers, Kentucky Lock and Dam						
Depth	**Pier 2**	**Pier 3**	**Pier 4**	**Pier 5**	**Pier 6**	**Pier 7**
300,000 cfs						
2/10	6.2	5.4	3.9	3.7	4.1	4.4
6/10	6.5	4.9	3.4	3.3	3.7	3.9
8/10	6.5	4.5	3.1	3.1	3.3	2.3
370,000 cfs						
2/10	7.1	3.0	1.3	4.9	4.5	2.3
6/10	6.8	2.2	1.1	3.7	4.0	3.9
8/10	7.0	1.8	1.0	3.6	3.3	4.1
Note: Velocities taken approximately 20 ft upstream of piers with Plan C installed, fps.						

Table 11 Velocities at Proposed Railroad Bridge Piers, Kentucky Lock and Dam Model											
Depth	**Pier 4**	**Pier 5**	**Pier 6**	**Pier 7**	**Pier 8**	**Pier 9**	**Pier 10**	**Pier 11**	**Pier 12**	**Pier 13**	**Pier 14**
300,000 cfs											
2/10	5.7	5.4	4.0	4.9	4.5	2.9	1.9	4.8	2.9	4.4	2.3
6/10	5.9	4.9	5.4	4.6	4.4	2.7	2.3	4.4	3.2	3.5	3.1
8/10	4.4	4.7	5.3	4.6	4.4	2.6	2.4	4.3	2.9	3.1	3.3
370,000 cfs											
2/10	5.7	5.3	3.3	2.3	0.9	2.6	1.9	4.3	4.6	4.0	2.6
6/10	6.1	4.9	2.8	1.4	1.0	2.1	2.5	3.4	4.0	3.0	2.4
8/10	5.6	4.7	2.8	1.4	0.9	2.2	2.2	3.4	3.5	2.7	2.0
Note: Velocities taken approximately 20 ft upstream of piers with Plan C installed, fps.											

Table 12 Velocities Off End of Proposed Dike, Plan B-2				
		Percentage Depth from Surface		
Discharge	**TW el**	**4/10**	**6/10**	**8/10**
35K	300.0	0.8	0.7	-
79K	303.6	2.6	2.4	1.8
100K	306.3	2.9	3.2	3.2
155K	316.0	4.8	4.6	4.1
300K	328.0	3.7	3.9	3.9
370K	344.0	3.1	3.2	2.9

Table 13
Velocities at Downstream End of Angled Training Work, Plan C, Kentucky Lock and Dam Model

300,000 cfs, 328.0 TW				370,000 cfs 344.0 TW			
Depth	Site 1	Site 2	Site 3	Depth	Site 1	Site 2	Site 3
2/10	5.8	5.9	5.5	2/10	6.1	5.9	5.8
4/10	5.1	5.0	4.4	4/10	5.6	5.7	5.4
6/10	4.3	4.9	4.3	6/10	5.0	5.0	4.8
8/10	3.7	4.3	4.2	8/10	4.7	4.8	4.2

Table 14
Velocities at Proposed Highway Bridge Piers, Kentucky Lock and Dam Model

Depth	Pier 2	Pier 3	Pier 4	Pier 5	Pier 6	Pier 7
35,000 cfs,300.0 TW						
2/10	-	-0.7	1.2	2.2	3.3	-
6/10	-	-0.7	1.2	2.0	3.1	-
8/10	-0.4	-0.6	0.7	1.7	2.8	-
302.0 TW						
2/10	-	-0.7	1.8	3.0	3.5	-
6/10	-0.6	-0.5	1.7	2.7	3.2	-
8/10	-	0.4	1.8	2.6	3.1	-
79,000 cfs, 303.6 TW						
2/10	-	-1.6	2.3	3.6	5.6	-
6/10	-2.2	-1.5	2.2	3.6	5.5	-
8/10	-	-1.7	2.1	3.5	5.3	-
305.0 TW						
2/10	-	-1.7	3.1	4.4	6.0	-
6/10	-3.4	-1.5	3.3	3.9	5.8	0.1
8/10	-	-1.3	3.2	3.8	5.5	-
100,000 cfs, 306.3 TW						
2/10	-	-1.5	3.9	5.0	5.2	-
6/10	-1.3	-1.3	3.9	4.7	5.3	0.1
8/10	-	-1.2	3.7	4.3	5.0	-
308.0 TW						
2/10	-	1.1	2.1	5.3	5.3	-
6/10	-0.5	1.1	2.0	4.9	5.6	0.1
8/10	-	1.1	1.9	4.6	5.6	-
310.0 TW						
2/10	-	1.6	2.5	5.8	5.8	-
6/10	-2.0	1.9	2.3	5.4	5.9	0.6
8/10	-	1.8	2.1	5.3	5.7	-

Note: Velocities taken approximately 20 ft upstream of piers with Plan B-2 installed, fps.

Table 15
Velocities at Proposed Railroad Bridge Piers, Kentucky Lock and Dam Model

Depth	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	Pier 12	Pier 13	Pier 14
35,000 cfs, 300.0 TW											
2/10	-	-0.6	-0.5	0.6	1.6	1.4	2.3	3.7	-	-	-
6/10	0.1	-0.7	-0.4	0.7	1.1	1.4	1.9	3.5	2.4	2.0	-
8/10	-	-0.7	-0.4	0.5	1.3	1.3	2.0	2.8	2.5	-	-
302.0 TW											
2/10	-	-1.3	-0.6	0.9	2.6	3.5	3.0	3.9	-	-	-
6/10	0.1	-1.4	-0.5	1.2	2.6	3.2	2.9	3.7	2.4	2.5	-
8/10	-	-1.5	-0.6	1.1	2.1	3.0	2.8	3.4	2.7	-	-
79,000 cfs, 303.6 TW											
2/10	-	-2.4	-1.0	1.3	3.6	4.1	4.0	5.7	2.9	-	-
6/10	0.1	-2.6	-1.1	1.4	3.7	4.3	3.8	5.5	3.5	3.4	-
8/10	-	-2.5	-0.9	1.2	3.2	3.8	3.9	5.3	4.1	-	-
305.0 TW											
2/10	-	-1.5	-1.3	1.7	4.5	5.8	5.0	6.0	2.9	-	-
6/10	-0.1	-3.1	-1.4	1.7	4.7	5.5	4.9	6.0	4.3	3.7	-
8/10	-	-3.1	-1.2	1.7	4.3	5.1	4.7	5.3	4.8	-	-
100,000 cfs, 306.3 TW											
Depth	Pier 4	Pier 5	Pier 6	Pier 7	Pier 8	Pier 9	Pier 10	Pier 11	Pier 12	Pier 13	Pier 14
2/10	-	-2.0	-1.9	2.7	4.7	5.3	4.4	4.9	2.4	-	-
6/10	-0.7	-2.7	-1.9	2.7	4.8	5.1	4.5	5.1	3.1	3.3	-
8/10	-	-2.8	-1.6	2.5	4.8	4.8	4.4	5.0	3.6	3.3	-
308.0 TW											
2/10	-	-0.8	0.7	1.1	3.0	4.5	3.8	4.6	2.8	-	-
6/10	-0.4	-0.8	0.8	1.2	3.0	4.9	4.3	5.0	3.7	3.9	2.6
8/10	-	-0.7	0.7	1.2	3.1	4.8	4.3	5.0	4.4	4.1	-
310.0 TW											
2/10	-	-0.8	1.8	2.3	2.7	4.6	4.1	5.3	2.8	-	-
6/10	-1.2	-1.0	1.9	2.5	2.7	4.9	5.3	5.5	3.6	4.3	3.3
8/10	-	-1.3	1.9	2.3	2.9	4.9	5.1	5.4	4.3	4.6	-

Note: Velocities taken approximately 20 ft upstream of piers with Plan B-2 installed, fps.

Table 16
Point Velocities, Kentucky Lock and Dam Model, 35,000 cfs Flow Condition

X-Sect	1	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	0.6	0.2	0.8
4 ft	-	-	-	-
6 ft	-	-	-	-
10 ft	-	-	-	-

X-Sect	1	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.2	0.6	0.7
4 ft	1.1	1.1	1.6	1.8
6 ft	1.7	2.0	2.1	2.0
10 ft	-	-	-	-

X-Sect	1	Point	4	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.8	0.3	0.6	0.3
4 ft	1.0	1.3	0.9	1.5
6 ft	1.6	1.7	1.6	1.9
10 ft	-	-	-	-

X-Sect	1	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	0.1	0.6	0.1
4 ft	1.6	0.9	1.1	0.6
6 ft	1.2	1.1	1.3	1.5
10 ft	-	-	-	-

X-Sect	2	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.6	0.1	0.1	0.5
4 ft	1.4	0.6	0.1	0.7
6 ft	0.4	1.6	1.4	1.9
10 ft	-	-	-	-

X-Sect	2	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.5	0.7	0.7	0.6
4 ft	1.4	1.1	0.7	1.4
6 ft	1.8	1.6	1.8	2.2
10 ft	-	-	-	-

X-Sect	2	Point	4	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.2	0.6	0.2	0.5
4 ft	0.1	1.9	1.4	1.7
6 ft	1.5	1.6	1.8	2.2
10 ft	-	-	-	-

X-Sect	2	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.1	0.1	0.3
4 ft	0.3	0.3	0.6	0.4
6 ft	1.3	1.0	1.2	1.6
10 ft	-	-	-	-

X-Sect	3	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.5	0.6	0.7	0.1
4 ft	-	-	-	-
6 ft	-	-	-	-
10 ft	-	-	-	-

X-Sect	3	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	2.0	0.5	0.6	0.9
4 ft	0.7	1.2	1.2	1.7
6 ft	2.5	2.0	1.8	2.2
10 ft	-	-	-	-

X-Sect	3	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.8	0.3	0.4	0.3
4 ft	0.9	0.9	1.1	1.1
6 ft	2.0	1.2	1.2	2.0
10 ft	-	-	-	-

X-Sect	3	Point	6	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	0.1	0.5	0.2
4 ft	0.3	0.8	0.5	0.7
6 ft	1.3	2.0	1.8	1.7
10 ft	-	-	-	-

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 16 (Concluded)

X-Sect	4	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.7	0.2	0.4
4 ft	-	-	-	-
6 ft	-	-	-	-
10 ft	-	-	-	-

X-Sect	4	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.7	0.7	0.6	0.2
4 ft	1.1	1.8	2.2	1.1
6 ft	-	-	-	-
10 ft	-	-	-	-

X-Sect	4	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	1.1	0.7	0.6
4 ft	1.4	2.0	2.0	1.7
6 ft	2.5	2.8	2.8	2.4
10 ft	-	-	-	-

X-Sect	4	Point	6	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	0.9	0.4	0.3
4 ft	0.5	1.4	1.2	0.9
6 ft	-	-	-	-
10 ft	-	-	-	-

X-Sect	5	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.1	0.5	0.5
4 ft	-	-	-	-
6 ft	-	-	-	
10 ft	-	-	-	-

X-Sect	5	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.6	0.1	0.5	0.6
4 ft	2.4	1.6	1.2	1.2
6 ft	1.8	1.5	1.7	1.9
10 ft	-	-	-	-

X-Sect	5	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.5	1.0	0.8	1.0
4 ft	2.0	1.4	1.2	1.1
6 ft	2.1	1.7	2.0	1.8
10 ft	-	-	-	-

X-Sect	5	Point	6	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.7	0.6	0.2	0.7
4 ft	0.6	0.8	0.6	0.6
6 ft	1.5	1.3	1.2	1.1
10 ft	-	-	-	-

Table 17
Point Velocities, Kentucky Lock and Dam Model, 79,000 cfs Flow Condition

X-Sect 1		Point 1			X-Sect 1		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.7	0.7	1.1	1.6	2 ft	1.7	0.9	0.5	1.9
4 ft	1.7	1.9	1.2	2.2	4 ft	3.1	2.1	3.0	3.0
6 ft	-	-	-	-	6 ft	3.6	3.5	3.6	3.6
10 ft	-	-	-	-	10 ft	3.9	4.2	4.3	4.0
X-Sect 1		**Point 4**			**X-Sect 1**		**Point 5**		
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	0.6	1.1	0.8	0.8	2 ft	0.1	0.6	0.9	0.5
4 ft	2.9	2.7	3.4	2.2	4 ft	1.7	1.4	0.9	1.2
6 ft	3.0	2.6	3.4	3.0	6 ft	2.6	2.9	2.7	2.6
10 ft	3.4	3.8	3.8	3.5	10 ft	2.9	3.3	3.0	2.9
X-Sect 2		**Point 1**			**X-Sect 2**		**Point 2**		
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.3	1.0	0.9	0.8	2 ft	2.1	1.4	1.0	1.5
4 ft	2.6	2.5	1.9	2.5	4 ft	4.1	4.3	3.3	3.7
6 ft	3.4	2.8	2.6	3.3	6 ft	4.3	4.4	4.4	4.0
10 ft	3.8	3.7	4.0	3.8	10 ft	4.8	4.7	4.7	4.5
X-Sect 2		**Point 4**			**X-Sect 2**		**Point 5**		
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	0.7	0.6	0.5	1.3	2 ft	2.9	0.4	0.8	0.2
4 ft	3.2	3.1	3.0	2.8	4 ft	1.2	1.4	1.8	1.1
6 ft	3.6	3.2	3.7	3.7	6 ft	2.6	2.9	2.5	2.4
10 ft	3.9	3.8	4.2	4.0	10 ft	3.0	3.3	3.2	3.1
X-Sect 3		**Point**	**1**		**X-Sect 3**		**Point 2**		
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.0	1.1	0.9	1.7	2 ft	1.9	1.3	1.2	1.4
4 ft	1.3	2.2	2.0	2.2	4 ft	3.6	3.2	3.3	3.0
6 ft	-	-	-	-	6 ft	4.5	3.9	4.2	3.8
10 ft	-	-	-	-	10 ft	4.7	4.9	5.1	4.7
X-Sect 3		**Point 5**			**X-Sect 3**		**Point 6**		
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.4	2.6	2.7	2.1	2 ft	0.6	1.2	0.3	1.2
4 ft	3.0	3.4	3.3	2.8	4 ft	2.0	2.1	2.0	1.8
6 ft	3.6	3.4	3.8	3.0	6 ft	2.4	2.3	2.9	2.5
10 ft	3.8	4.2	4.0	3.9	10 ft	3.0	3.2	3.2	2.9

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 17 (Concluded)

X-Sect 4		Point 1			X-Sect 4		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.6	1.6	0.9	1.0	2 ft	0.5	2.4	2.1	2.2
4 ft	1.6	1.2	0.9	1.4	4 ft	3.6	2.9	2.4	2.9
6 ft	-	-	-	-	6 ft	3.2	3.3	3.1	3.9
10 ft	-	-	-	-	10 ft	4.7	5.4	5.2	5.0
X-Sect 4		Point 5			X-Sect 4		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	1.1	0.8	1.0	2 ft	0.6	1.6	1.1	1.2
4 ft	1.2	4.2	3.5	3.6	4 ft	2.1	2.8	1.9	2.3
6 ft	4.4	4.9	4.9	4.6	6 ft	4.1	3.2	2.1	2.2
10 ft	5.1	5.3	5.1	4.9	10 ft	4.4	4.5	4.5	3.8
X-Sect 5		Point 1			X-Sect 5		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.2	1.8	1.3	1.2	2 ft	0.3	1.7	1.4	1.0
4 ft	0.6	2.5	2.6	2.4	4 ft	2.5	2.2	2.6	2.1
6 ft	-	-	-	-	6 ft	4.2	3.8	3.6	3.3
10 ft	-	-	-	-	10 ft	4.9	4.8	4.8	4.6
X-Sect 5		Point 5			X-Sect 5		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	0.6	0.7	0.5	2 ft	0.6	0.8	0.7	0.9
4 ft	1.4	1.0	1.3	1.5	4 ft	2.3	1.7	1.7	2.1
6 ft	3.5	3.2	3.8	3.2	6 ft	3.3	2.0	2.5	2.9
10 ft	4.4	4.0	4.3	4.2	10 ft	3.5	3.6	3.4	3.2

Table 18
Point Velocities, Kentucky Lock and Dam Model, 100,000 cfs Flow Condition

X-Sect	1	Point	1		X-Sect	1	Point	2	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.5	2.2	2.4	3.1	2 ft	2.2	2.0	1.5	1.8
4 ft	2.1	2.8	2.4	2.3	4 ft	2.7	2.7	3.1	3.5
6 ft	2.8	3.1	3.5	2.9	6 ft	3.7	3.4	4.3	4.1
10 ft	-	-	-	-	10 ft	4.4	4.7	4.3	4.5
X-Sect	**1**	**Point**	**4**		**X-Sect**	**1**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.1	1.6	1.6	1.2	2 ft	0.4	1.3	1.3	0.9
4 ft	2.2	2.8	2.2	2.0	4 ft	1.8	1.6	1.5	1.8
6 ft	3.1	3.6	2.7	3.5	6 ft	2.7	2.9	3.3	3.4
10 ft	4.0	4.0	3.9	3.9	10 ft	3.9	4.2	4.0	4.3
X-Sect	**2**	**Point**	**1**		**X-Sect**	**2**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.5	0.7	1.3	0.6	2 ft	2.6	2.0	2.2	2.0
4 ft	2.4	1.5	1.6	2.6	4 ft	3.1	3.9	3.4	3.3
6 ft	2.9	4.0	3.2	3.3	6 ft	4.2	4.6	4.4	3.8
10 ft	4.1	4.4	4.2	4.5	10 ft	4.8	5.1	5.0	5.1
X-Sect	**2**	**Point**	**4**		**X-Sect**	**2**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	0.9	1.0	1.0	0.7	2 ft	0.1	0.1	0.5	0.6
4 ft	3.0	2.3	2.3	2.7	4 ft	1.5	1.1	1.2	1.5
6 ft	3.5	3.9	3.5	4.1	6 ft	2.6	2.8	3.1	2.7
10 ft	4.6	4.8	4.7	4.6	10 ft	3.3	3.5	3.3	4.0
X-Sect	**3**	**Point**	**1**		**X-Sect**	**3**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	0.7	1.7	0.9	1.8	2 ft	1.4	1.7	1.3	0.6
4 ft	2.4	2.1	2.6	2.6	4 ft	3.3	1.9	1.3	1.4
6 ft	3.6	4.5	3.6	4.4	6 ft	3.8	4.1	4.4	5.1
10 ft	-	-	-	-	10 ft	5.0	5.4	5.2	5.3
X-Sect	**3**	**Point**	**5**		**X-Sect**	**3**	**Point**	**6**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	0.8	0.1	0.5	1.1	2 ft	0.5	0.6	0.4	0.7
4 ft	1.9	3.2	3.1	3.0	4 ft	0.2	1.9	1.2	1.0
6 ft	2.4	4.3	4.2	3.9	6 ft	1.7	2.8	2.5	2.8
10 ft	4.0	4.5	4.6	4.7	10 ft	3.3	3.1	3.4	3.5

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 18 (Concluded)

X-Sect 4		Point 1		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.2	0.7	1.0	0.9
4 ft	0.7	1.9	1.1	1.4
6 ft	2.6	2.0	2.5	2.2
10 ft	-	-	-	-

X-Sect 4		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.2	0.5	0.7	1.0
4 ft	1.7	1.8	2.1	2.4
6 ft	3.3	4.0	4.6	4.7
10 ft	4.9	5.5	5.5	5.2

X-Sect 4		Point 5		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.0	1.7	0.5	0.3
4 ft	2.3	2.8	2.2	1.8
6 ft	2.9	4.5	4.3	3.9
10 ft	4.9	5.3	5.3	5.1

X-Sect 4		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.8	0.3	0.1	0.3
4 ft	1.2	1.3	1.1	1.1
6 ft	2.3	3.3	3.2	3.5
10 ft	3.9	4.6	3.7	4.5

X-Sect 5		Point 1		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	0.5	0.5	0.6
4 ft	2.0	1.9	2.1	1.7
6 ft	2.8	3.4	2.8	3.4
10 ft	-	-	-	-

X-Sect 5		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.5	1.0	0.4
4 ft	0.4	1.8	2.0	1.3
6 ft	2.1	4.1	4.1	4.0
10 ft	4.1	5.0	5.0	4.8

X-Sect 5		Point 5		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.2	1.3	1.7	0.7
4 ft	1.6	2.0	1.2	1.6
6 ft	3.5	4.0	3.6	3.6
10 ft	3.8	4.6	4.4	4.3

X-Sect 5		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	0.7	0.1	0.4
4 ft	1.2	1.3	0.9	1.0
6 ft	3.1	2.3	2.7	2.6
10 ft	3.5	3.6	3.4	3.7

Table 19
Point Velocities, Kentucky Lock and Dam Model, 155,000 cfs Flow Condition

X-Sect	**1**	**Point**	**1**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.9	1.8	2.5	2.4
4 ft	3.1	2.5	2.7	2.7
6 ft	3.4	3.3	3.5	3.4
10 ft	3.5	3.3	3.9	3.8

X-Sect	**1**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	1.5	2.3	1.6	2.6
4 ft	3.0	3.3	2.6	3.4
6 ft	3.7	4.1	4.5	4.1
10 ft	4.2	4.5	4.6	4.6

X-Sect	1	Point	4	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.8	0.9	0.6	1.3
4 ft	2.9	3.4	2.7	2.8
6 ft	3.4	3.4	3.3	3.6
10 ft	3.7	4.0	4.3	3.9

X-Sect	1	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.7	1.0	1.6	0.9
4 ft	1.7	2.4	2.2	2.4
6 ft	2.0	2.6	2.9	3.1
10 ft	2.7	3.4	3.4	3.4

X-Sect	2	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.8	1.3	1.4	0.8
4 ft	2.4	2.3	2.3	2.3
6 ft	3.1	3.3	2.8	3.7
10 ft	4.3	4.6	4.3	4.4

X-Sect	2	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.3	1.0	1.5	1.4
4 ft	1.7	2.8	3.5	3.8
6 ft	5.0	4.4	4.6	4.6
10 ft	4.6	4.9	5.0	5.1

X-Sect	2	Point	4	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.7	0.4	0.2	0.7
4 ft	0.6	2.2	1.2	1.4
6 ft	2.2	3.1	3.4	3.5
10 ft	3.7	4.1	4.3	4.1

X-Sect	2	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.1	0.4	0.6	0.8
4 ft	0.6	1.0	1.3	1.8
6 ft	2.0	2.1	2.4	2.0
10 ft	2.7	3.4	3.0	3.1

X-Sect	3	Point	1	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	1.8	1.2	1.5
4 ft	1.4	2.3	2.0	2.1
6 ft	2.9	3.3	3.1	3.4
10 ft	3.4	4.2	4.2	4.5

X-Sect	3	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	1.0	0.8	1.4
4 ft	2.0	2.0	2.4	2.6
6 ft	3.6	3.1	3.5	3.7
10 ft	4.2	4.9	4.9	4.7

X-Sect	3	Point	5	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.6	0.8	1.2	1.4
4 ft	1.8	1.3	1.6	2.1
6 ft	2.5	3.3	3.4	3.2
10 ft	3.3	3.7	3.7	3.9

X-Sect	3	Point	6	
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.3	0.9	1.1	1.1
4 ft	0.5	1.2	1.4	1.2
6 ft	2.7	3.0	2.8	3.0
10 ft	2.8	3.2	3.1	2.9

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 19 (Concluded)

X-Sect 4		Point 1			X-Sect 4		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	1.3	1.3	0.8	2 ft	1.4	1.4	1.4	1.2
4 ft	0.7	2.7	2.7	3.2	4 ft	1.5	1.8	2.1	1.6
6 ft	1.7	3.5	3.7	3.8	6 ft	3.1	3.9	4.2	4.3
10 ft	3.7	4.3	4.1	4.1	10 ft	4.2	4.8	4.8	4.8
X-Sect 4		Point 5			X-Sect 4		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.3	0.6	0.9	1.2	2 ft	0.6	0.7	0.5	0.4
4 ft	1.4	1.8	1.1	1.5	4 ft	0.6	0.9	0.4	0.7
6 ft	3.1	3.1	3.0	3.3	6 ft	1.7	3.2	2.8	2.4
10 ft	4.0	3.9	4.0	4.2	10 ft	3.4	3.2	3.5	3.2
X-Sect 5		Point 1			X-Sect 5		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.6	0.9	0.3	0.8	2 ft	0.3	0.4	1.2	0.7
4 ft	2.2	2.1	2.1	2.4	4 ft	2.0	2.6	2.1	2.8
6 ft	2.9	2.9	3.5	3.7	6 ft	2.4	3.8	3.9	4.1
10 ft	3.9	4.2	3.9	4.2	10 ft	4.1	4.1	4.6	4.8
X-Sect 5		Point 5			X-Sect 5		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	0.4	0.3	0.4	0.7	2 ft	0.1	0.5	0.3	0.4
4 ft	0.9	2.2	1.4	2.4	4 ft	0.6	1.7	1.4	1.4
6 ft	2.4	2.6	2.9	3.0	6 ft	1.4	2.1	1.8	2.3
10 ft	4.1	3.7	3.9	3.7	10 ft	2.6	3.0	3.0	3.2

Table 20
Point Velocities, Kentucky Lock and Dam Model, 300,000 cfs Flow Condition

X-Sect	1	Point	1		X-Sect	1	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.1	1.9	2.4	3.8	2 ft	4.3	2.4	2.0	3.6
4 ft	4.3	3.9	3.7	4.1	4 ft	4.8	4.0	4.5	4.3
6 ft	4.4	4.4	4.4	4.5	6 ft	5.1	5.0	4.7	4.9
10 ft	4.7	4.5	4.7	4.4	10 ft	5.1	5.2	5.5	5.3
X-Sect	**1**	**Point**	**4**		**X-Sect**	**1**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.3	2.3	2.1	2.7	2 ft	4.0	2.1	1.7	1.9
4 ft	4.4	3.2	3.9	4.1	4 ft	4.4	3.4	3.1	4.1
6 ft	4.9	4.1	3.9	4.4	6 ft	4.9	4.4	4.3	4.4
10 ft	5.1	5.2	5.2	5.4	10 ft	5.4	5.4	5.1	5.2
X-Sect	**2**	**Point**	**1**		**X-Sect**	**2**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.2	1.5	1.9	2.2	2 ft	3.9	1.9	1.6	3.4
4 ft	4.4	3.7	4.0	2.7	4 ft	4.9	2.6	3.2	4.4
6 ft	5.1	4.3	4.3	4.6	6 ft	5.0	5.2	4.6	5.0
10 ft	5.2	5.3	5.2	5.1	10 ft	5.3	5.6	5.4	5.5
X-Sect	**2**	**Point**	**4**		**X-Sect**	**2**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.6	0.8	0.8	1.0	2 ft	4.0	1.1	1.4	0.8
4 ft	5.3	2.2	2.6	2.9	4 ft	3.8	3.0	3.9	3.5
6 ft	5.4	5.3	5.0	5.0	6 ft	4.8	4.1	4.9	4.2
10 ft	6.0	6.0	5.6	5.8	10 ft	5.2	5.0	5.2	4.8
X-Sect	**3**	**Point**	**1**		**X-Sect**	**3**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.3	1.7	2.2	1.4	2 ft	4.3	2.7	2.6	2.5
4 ft	4.5	3.1	2.8	2.3	4 ft	4.9	2.7	2.7	2.3
6 ft	4.8	3.7	4.0	4.6	6 ft	5.3	4.6	4.0	4.3
10 ft	5.2	5.3	5.1	5.3	10 ft	5.6	5.7	5.4	5.4
X-Sect	**3**	**Point**	**5**		**X-Sect**	**3**	**Point**	**6**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.5	1.1	1.5	1.1	2 ft	3.9	1.5	1.1	1.3
4 ft	4.7	2.9	3.0	3.1	4 ft	3.9	2.2	2.6	2.9
6 ft	4.9	4.4	4.6	4.1	6 ft	4.8	3.3	3.1	3.0
10 ft	5.2	5.4	5.2	5.0	10 ft	5.0	5.0	4.9	4.5

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 20 (Concluded)				
X-Sect	**4**	**Point**	**1**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.6	2.0	1.5	1.4
4 ft	4.3	3.9	3.7	3.1
6 ft	5.0	4.0	4.7	4.2
10 ft	5.3	5.0	5.3	5.0
X-Sect	**4**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.6	1.4	1.2	0.7
4 ft	4.8	4.2	3.9	3.9
6 ft	5.3	5.0	5.4	5.1
10 ft	5.6	5.8	5.6	5.4
X-Sect	**4**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.1	1.1	1.4	1.6
4 ft	4.6	2.9	2.2	2.3
6 ft	4.9	4.2	4.0	4.5
10 ft	5.3	5.1	5.2	5.0
X-Sect	**4**	**Point**	**6**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.5	1.0	1.0	0.8
4 ft	3.8	1.7	2.3	1.3
6 ft	4.4	3.9	3.5	3.5
10 ft	4.8	4.5	4.3	4.4
X-Sect	**5**	**Point**	**1**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.2	1.2	1.3	1.0
4 ft	4.3	4.0	4.5	4.0
6 ft	5.1	4.5	4.8	3.5
10 ft	5.2	5.0	5.3	5.2
X-Sect	**5**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.8	0.9	1.1	0.9
4 ft	4.8	2.8	2.5	3.0
6 ft	5.4	4.7	4.2	5.2
10 ft	5.7	5.7	5.6	5.5
X-Sect	**5**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.5	1.5	1.0	1.0
4 ft	4.4	2.8	3.4	2.8
6 ft	4.4	3.9	3.8	3.5
10 ft	5.0	4.6	4.9	4.7
X-Sect	**5**	**Point**	**6**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.6	1.5	1.1	1.5
4 ft	3.6	2.1	1.7	2.3
6 ft	4.0	3.0	3.5	2.9
10 ft	4.2	3.9	4.1	3.9

Table 21
Point Velocities, Kentucky Lock and Dam Model, 370,000 cfs Flow Condition

X-Sect	1	Point	1		X-Sect	1	Point	2	
Height	Base	Plan B	Plan B-1	Plan B-2	Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.1	2.4	2.6	2.3	2 ft	4.4	1.3	1.2	2.1
4 ft	4.2	2.9	2.9	2.8	4 ft	5.1	2.7	2.6	2.7
6 ft	4.4	3.3	3.4	3.3	6 ft	5.0	3.6	3.7	3.5
10 ft	4.4	3.4	3.6	3.3	10 ft	5.8	3.9	3.9	4.0
X-Sect	**1**	**Point**	**4**		**X-Sect**	**1**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.7	1.8	1.8	1.8	2 ft	4.8	1.2	1.6	2.2
4 ft	3.6	1.9	1.9	1.0	4 ft	5.3	2.8	2.7	2.1
6 ft	4.3	2.4	2.5	2.7	6 ft	5.6	3.4	3.5	3.2
10 ft	4.6	2.8	2.4	2.7	10 ft	5.9	3.8	3.8	3.8
X-Sect	**2**	**Point**	**1**		**X-Sect**	**2**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.7	1.0	1.1	1.2	2 ft	4.1	0.6	1.2	1.2
4 ft	4.9	3.1	2.9	2.6	4 ft	4.8	2.2	2.3	2.4
6 ft	5.1	3.4	3.6	3.2	6 ft	5.1	2.9	3.1	3.3
10 ft	5.4	3.9	4.2	3.8	10 ft	5.4	3.3	3.4	3.6
X-Sect	**2**	**Point**	**4**		**X-Sect**	**2**	**Point**	**5**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.6	1.5	1.4	2.0	2 ft	2.3	1.2	1.5	0.8
4 ft	5.5	2.3	2.5	2.4	4 ft	5.1	1.1	0.8	1.2
6 ft	5.6	3.4	3.2	2.8	6 ft	5.4	2.7	3.2	3.0
10 ft	6.2	3.7	3.9	3.7	10 ft	5.6	3.7	3.3	3.5
X-Sect	**3**	**Point**	**1**		**X-Sect**	**3**	**Point**	**2**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	4.3	1.5	1.8	2.1	2 ft	3.8	1.9	1.3	1.8
4 ft	5.5	2.5	2.5	2.7	4 ft	5.5	3.2	2.8	3.4
6 ft	5.5	3.8	4.3	3.6	6 ft	5.7	4.2	4.2	4.2
10 ft	5.9	5.4	5.3	4.3	10 ft	6.3	5.1	5.0	4.4
X-Sect	**3**	**Point**	**5**		**X-Sect**	**3**	**Point**	**6**	
Height	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**	**Height**	**Base**	**Plan B**	**Plan B-1**	**Plan B-2**
2 ft	3.9	1.5	1.5	1.4	2 ft	3.0	0.5	0.7	0.8
4 ft	4.9	3.0	2.9	2.4	4 ft	4.2	1.9	2.3	2.0
6 ft	5.2	3.6	3.7	3.6	6 ft	4.4	3.7	3.3	3.1
10 ft	5.7	4.3	4.0	3.8	10 ft	4.6	4.1	3.9	3.6

(Continued)

Note: Height in feet above bottom, velocities in feet per second.

Table 21 (Concluded)

X-Sect 4		Point 1		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.0	1.3	1.1	1.6
4 ft	4.5	3.1	3.0	2.2
6 ft	5.2	3.3	3.5	3.7
10 ft	5.5	4.3	4.4	4.2

X-Sect 4		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.3	1.3	2.0	1.0
4 ft	5.1	3.2	3.7	3.2
6 ft	5.8	4.1	4.6	4.7
10 ft	6.0	5.0	5.0	4.5

X-Sect 4		Point 5		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.2	1.9	1.7	2.0
4 ft	5.0	2.9	2.7	3.1
6 ft	5.4	4.3	4.5	4.1
10 ft	5.6	5.0	5.0	4.5

X-Sect 4		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	1.7	1.3	1.5	1.2
4 ft	3.8	2.1	1.8	2.6
6 ft	4.3	2.7	3.3	3.3
10 ft	4.5	4.2	4.1	3.9

X-Sect 5		Point 1		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.3	1.3	1.5	1.1
4 ft	5.1	2.3	2.1	2.8
6 ft	5.4	3.9	3.8	3.7
10 ft	5.9	4.5	4.3	4.2

X-Sect 5		Point 2		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.4	1.6	1.4	1.5
4 ft	5.4	1.9	2.5	3.4
6 ft	5.6	3.3	3.5	4.0
10 ft	6.1	4.3	4.6	4.2

X-Sect 5		Point 5		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	4.0	1.9	1.5	1.3
4 ft	4.1	2.0	2.1	2.2
6 ft	4.9	3.5	3.4	3.1
10 ft	5.1	4.1	4.3	4.2

X-Sect 5		Point 6		
Height	Base	Plan B	Plan B-1	Plan B-2
2 ft	2.2	1.5	2.0	0.9
4 ft	3.3	1.8	1.5	1.5
6 ft	3.8	2.7	3.3	3.1
10 ft	4.0	3.7	3.8	3.5

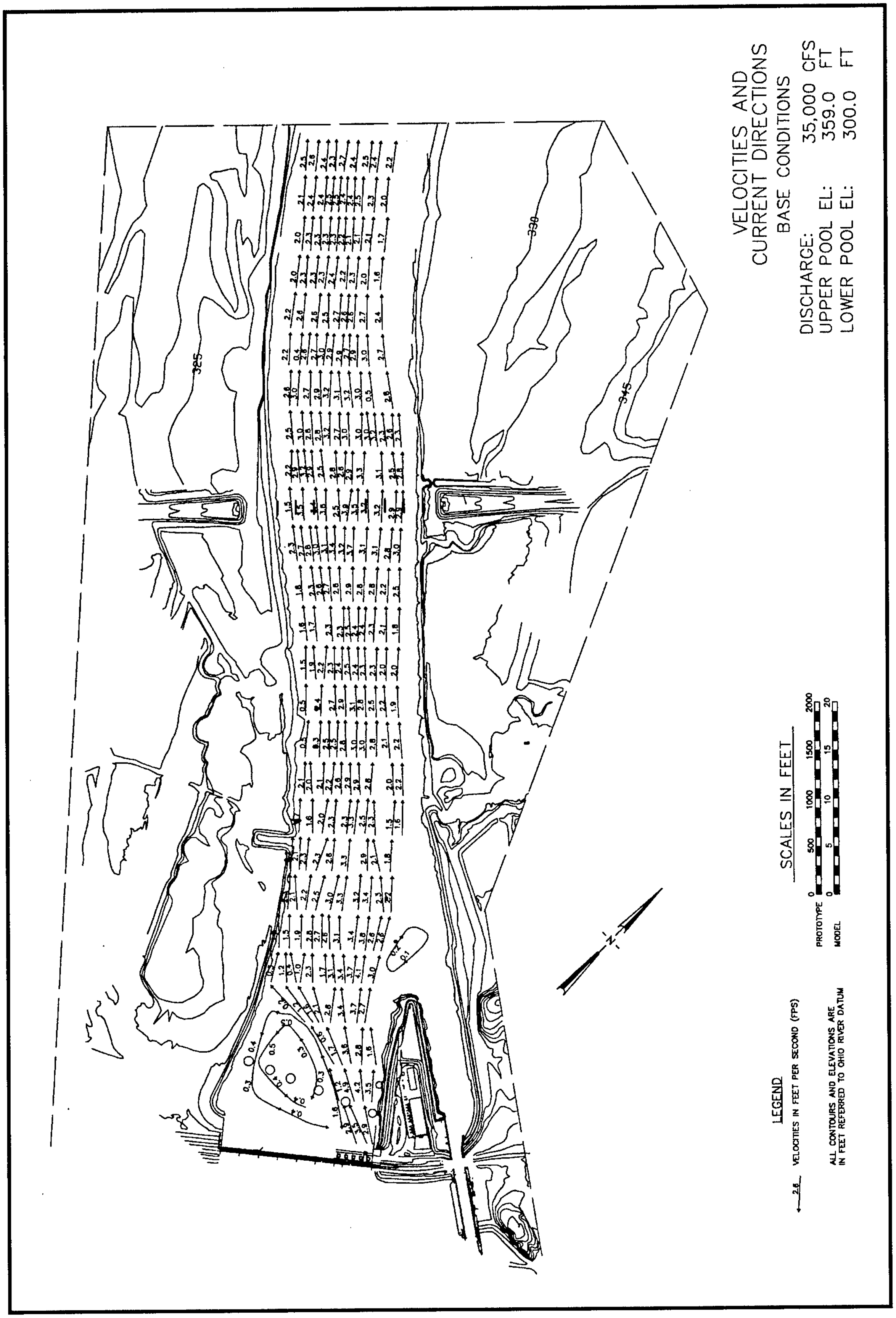
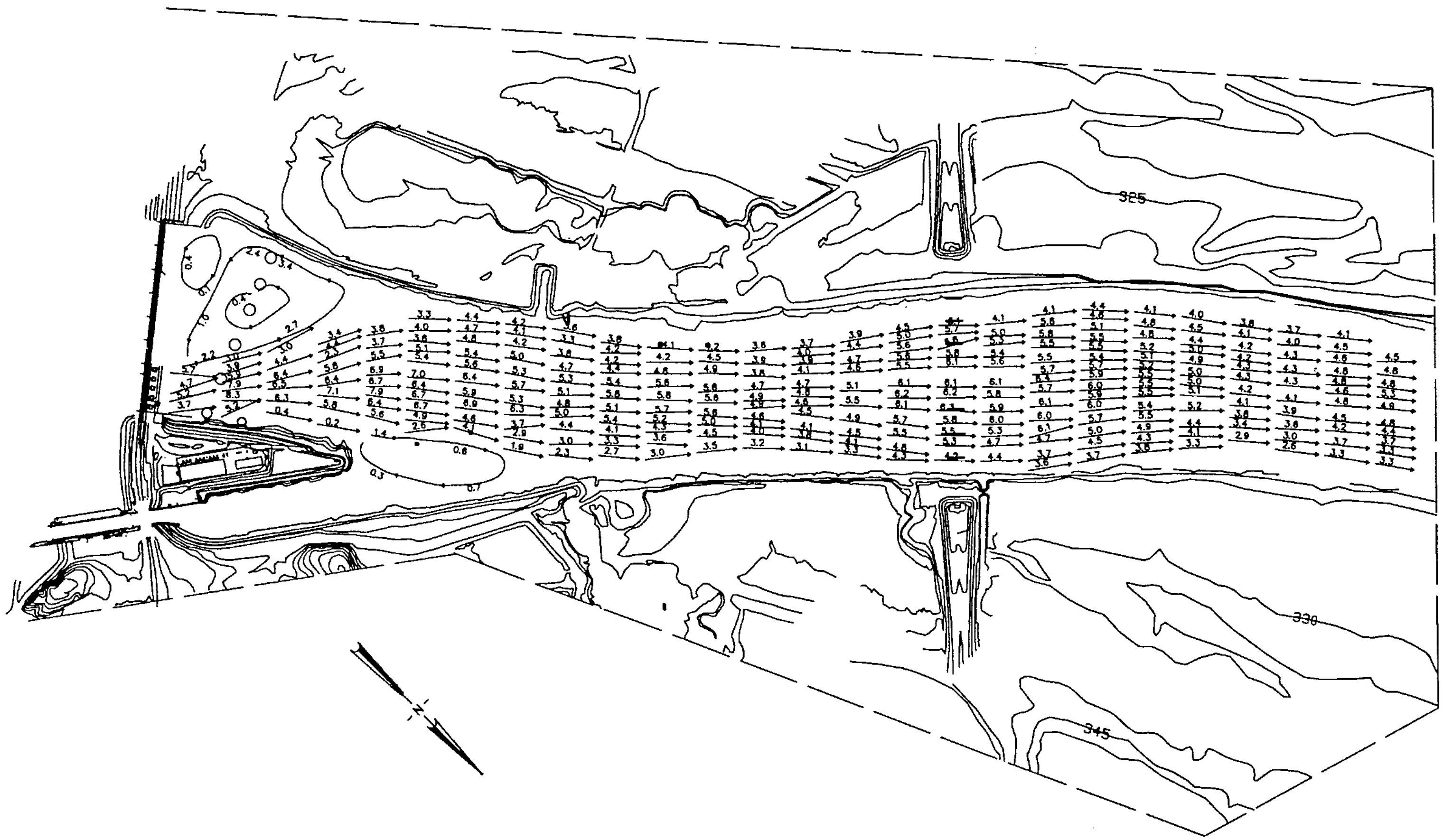

VELOCITIES AND
CURRENT DIRECTIONS
BASE CONDITIONS
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345

Plate 1



VELOCITIES AND
CURRENT DIRECTIONS
BASE CONDITIONS

DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT

LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

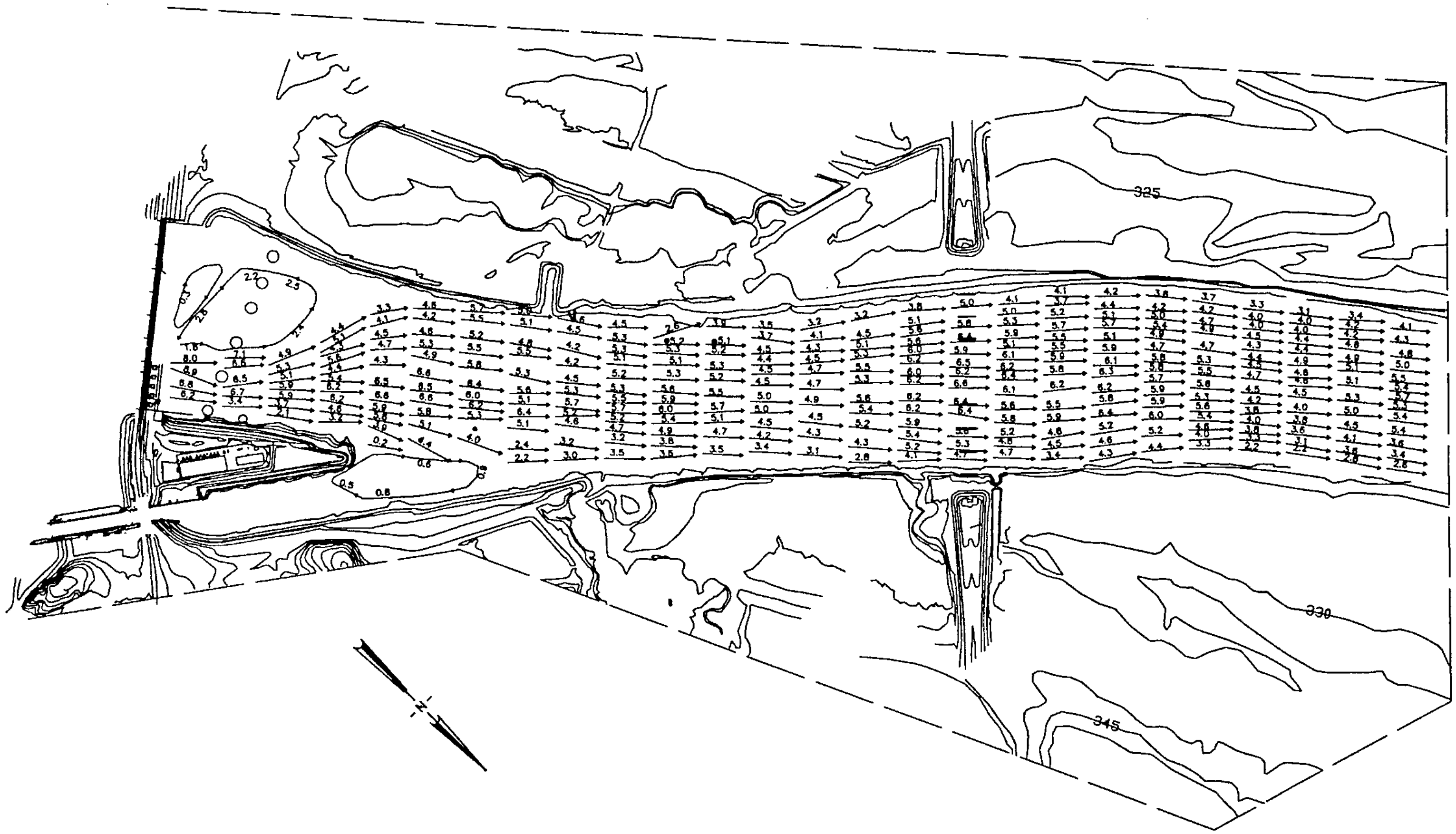
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

Plate 2



VELOCITIES AND CURRENT DIRECTIONS

BASE CONDITIONS

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT

LEGEND

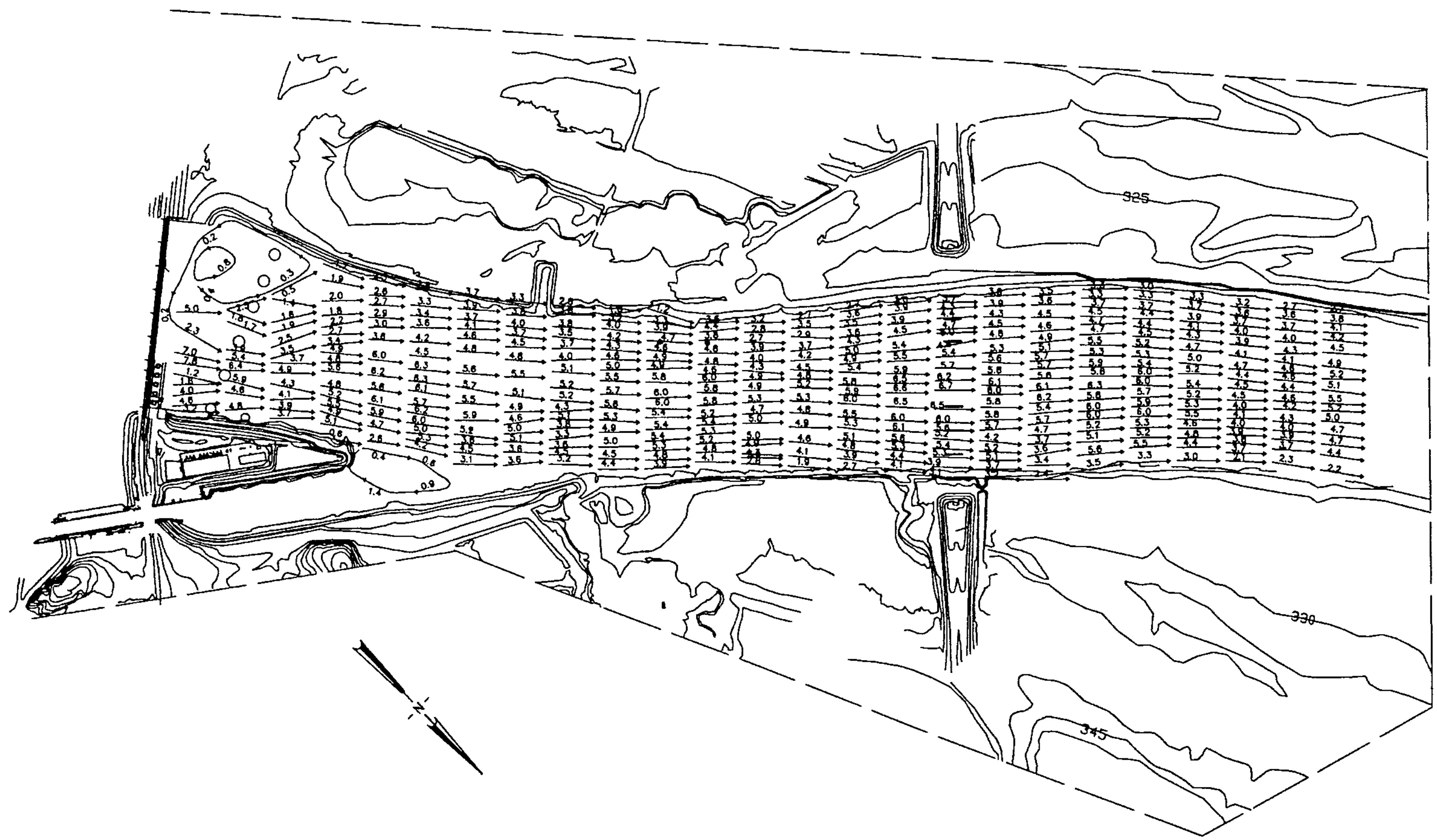
2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

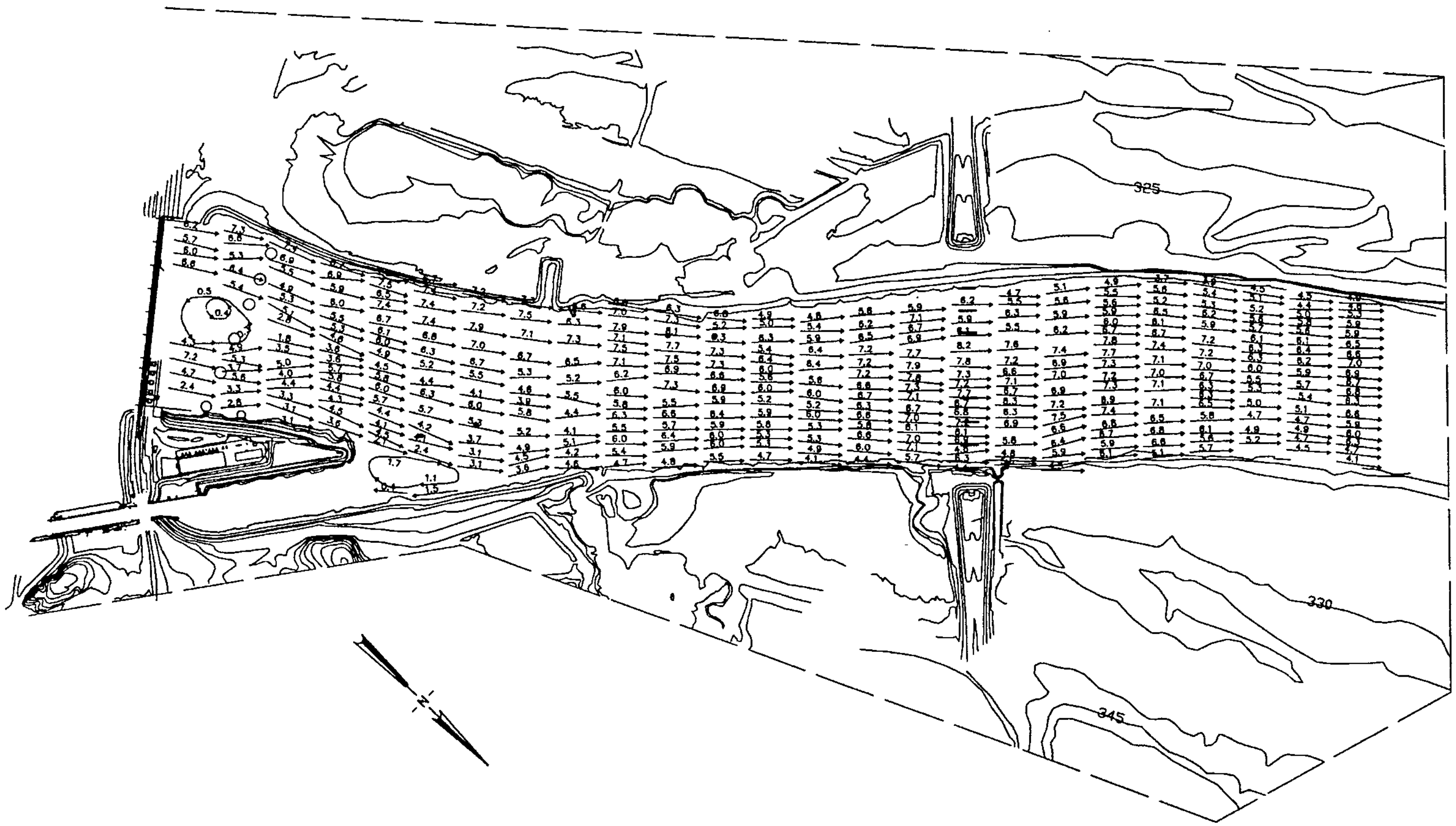
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

BASE CONDITIONS

DISCHARGE:	155,000	CFS
UPPER POOL EL:	359.0	FT
LOWER POOL EL:	316.0	FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

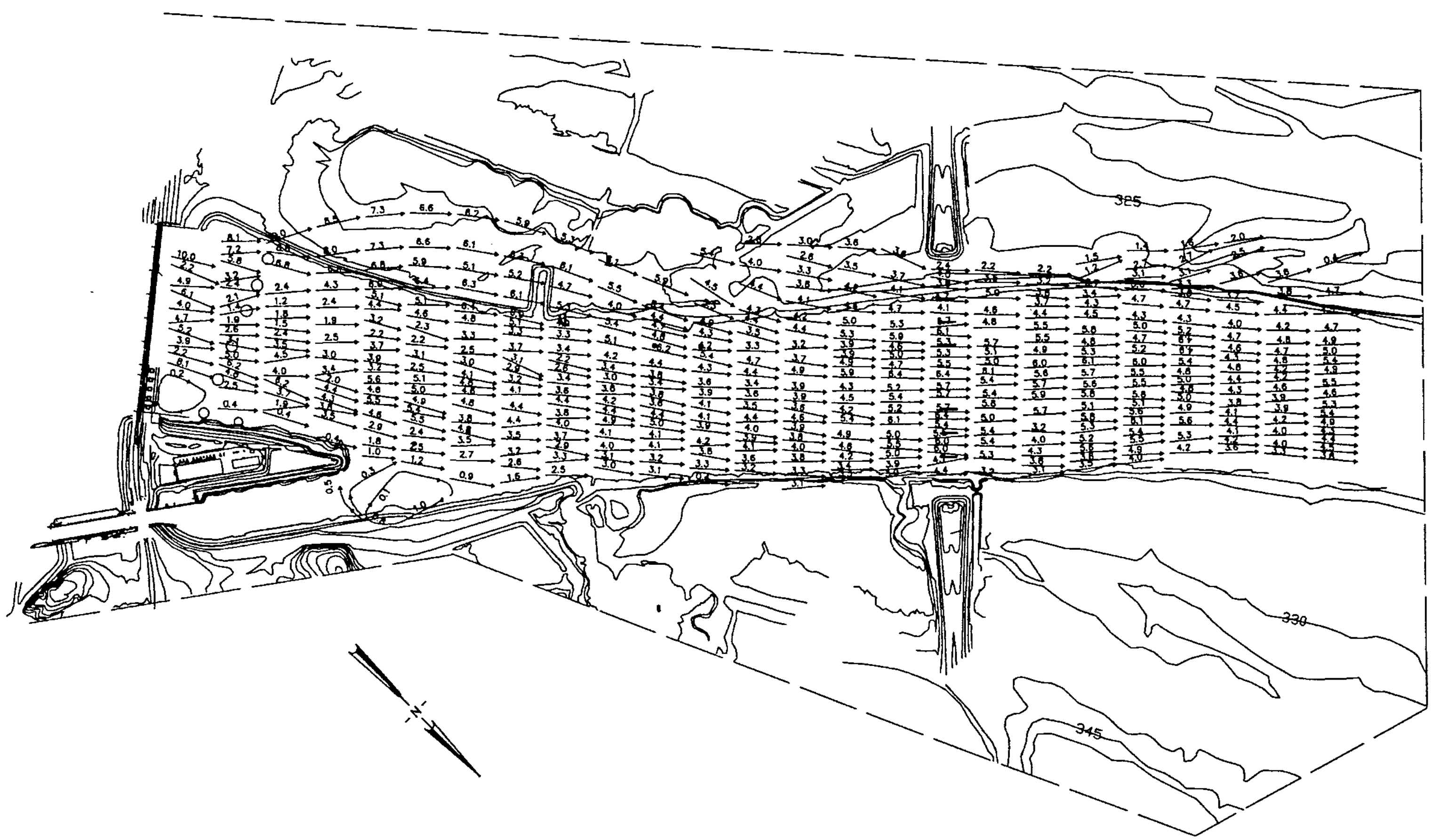
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

BASE CONDITIONS

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

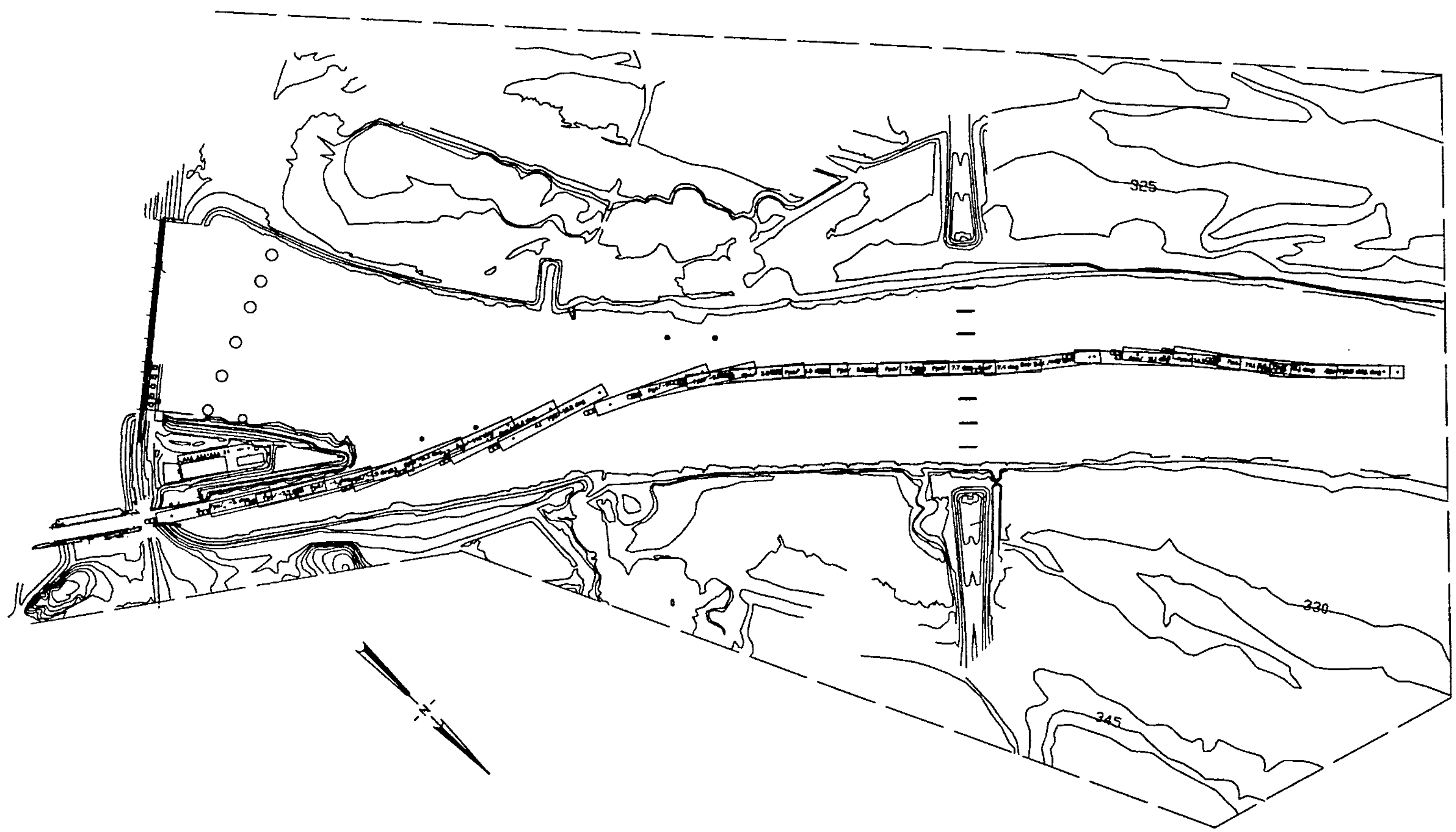
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

BASE CONDITIONS

DISCHARGE:	370,000	CFS
UPPER POOL EL:	368.3	FT
LOWER POOL EL:	344.0	FT



TOW TRACKS, DOWNBOUND
BASE CONDITIONS

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT

LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

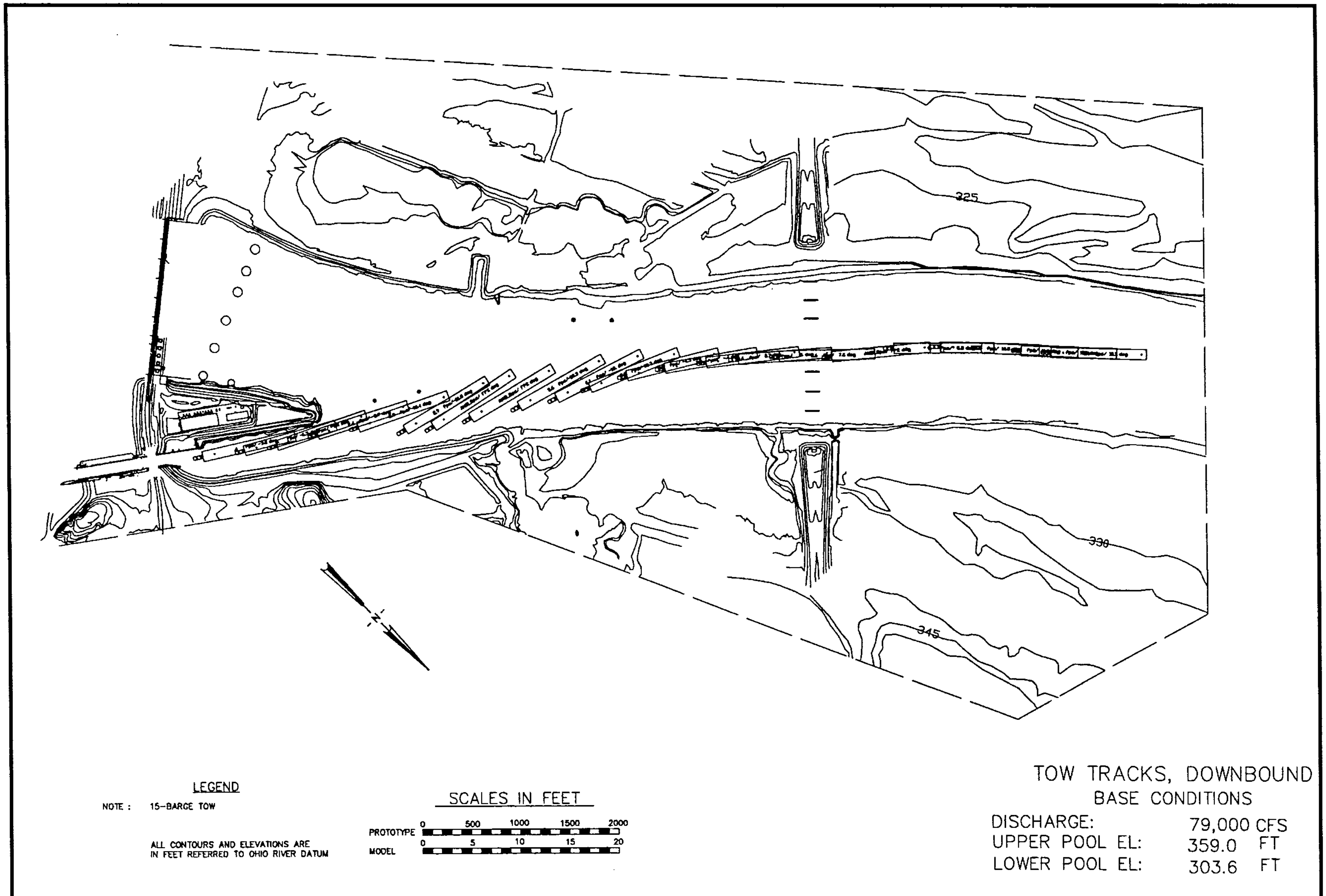
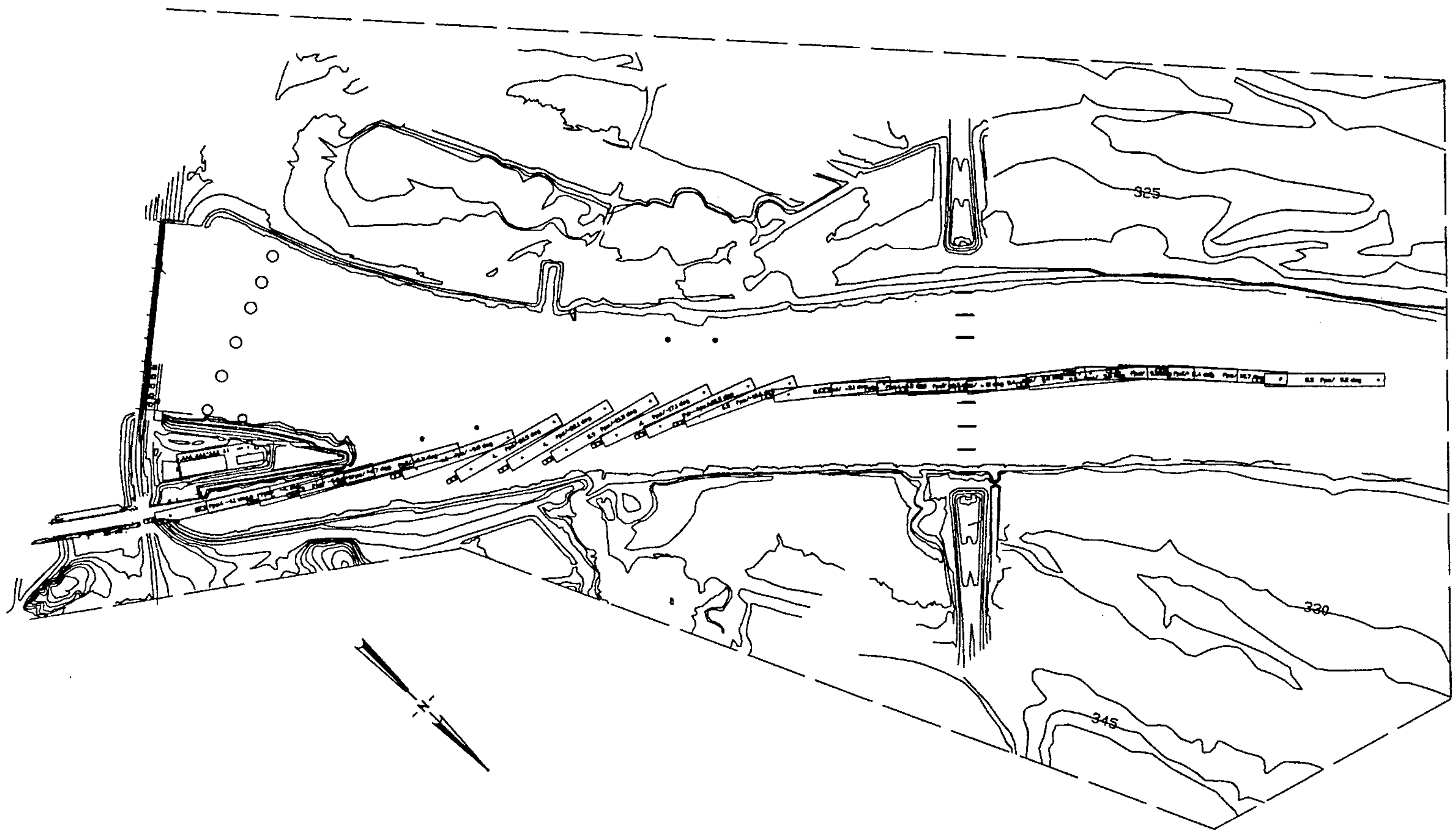

325
330
345
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
N
TOW TRACKS, DOWNBOUND
BASE CONDITIONS
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT

Plate 8



TOW TRACKS, DOWNBOUND
BASE CONDITIONS

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT

LEGEND

NOTE : 15–BARGE TOW

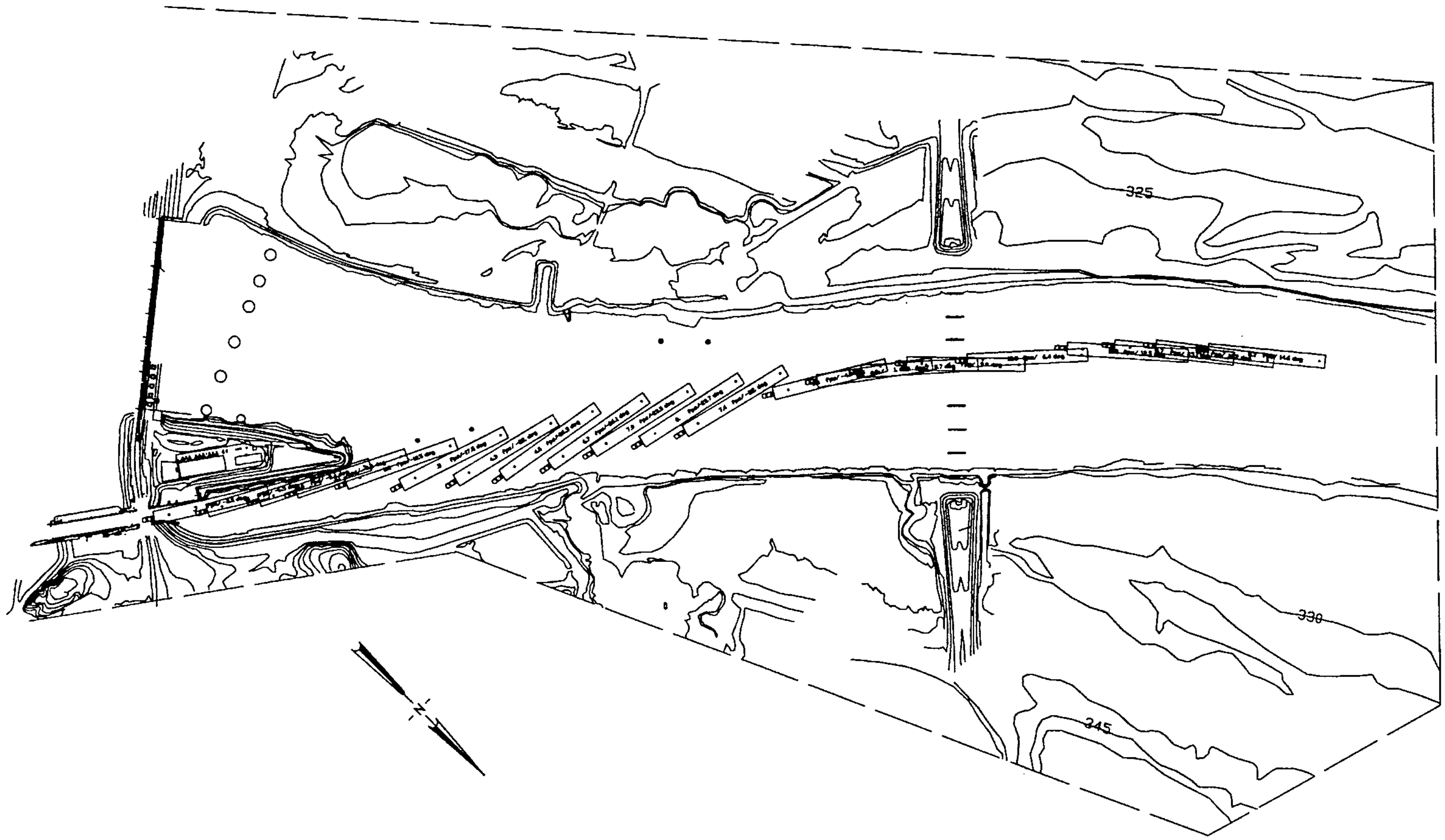
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

Plate 9



TOW TRACKS, DOWNBOUND
BASE CONDITIONS

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT

LEGEND

NOTE : 15-BARGE TOW

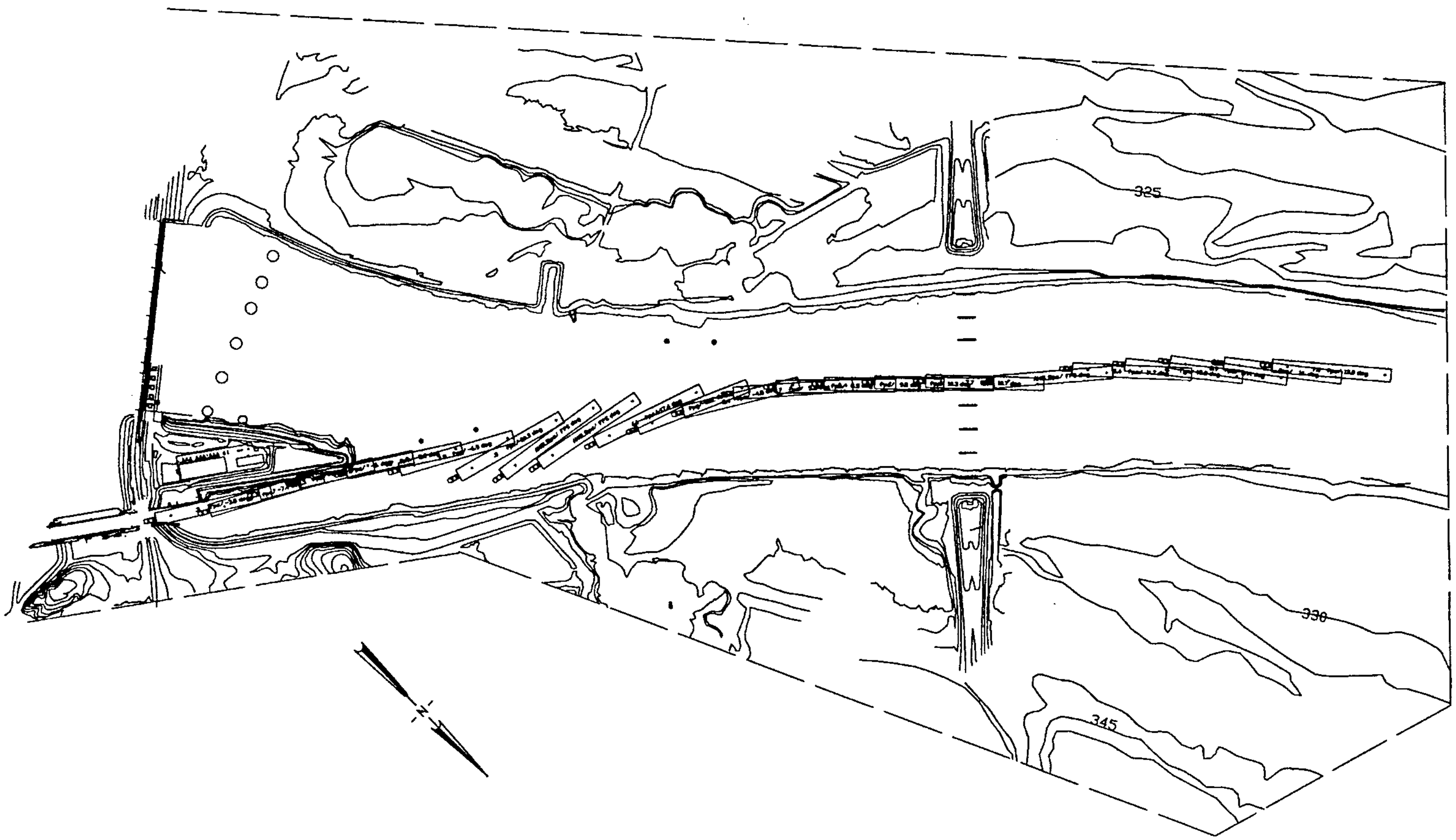
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

Plate 10



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

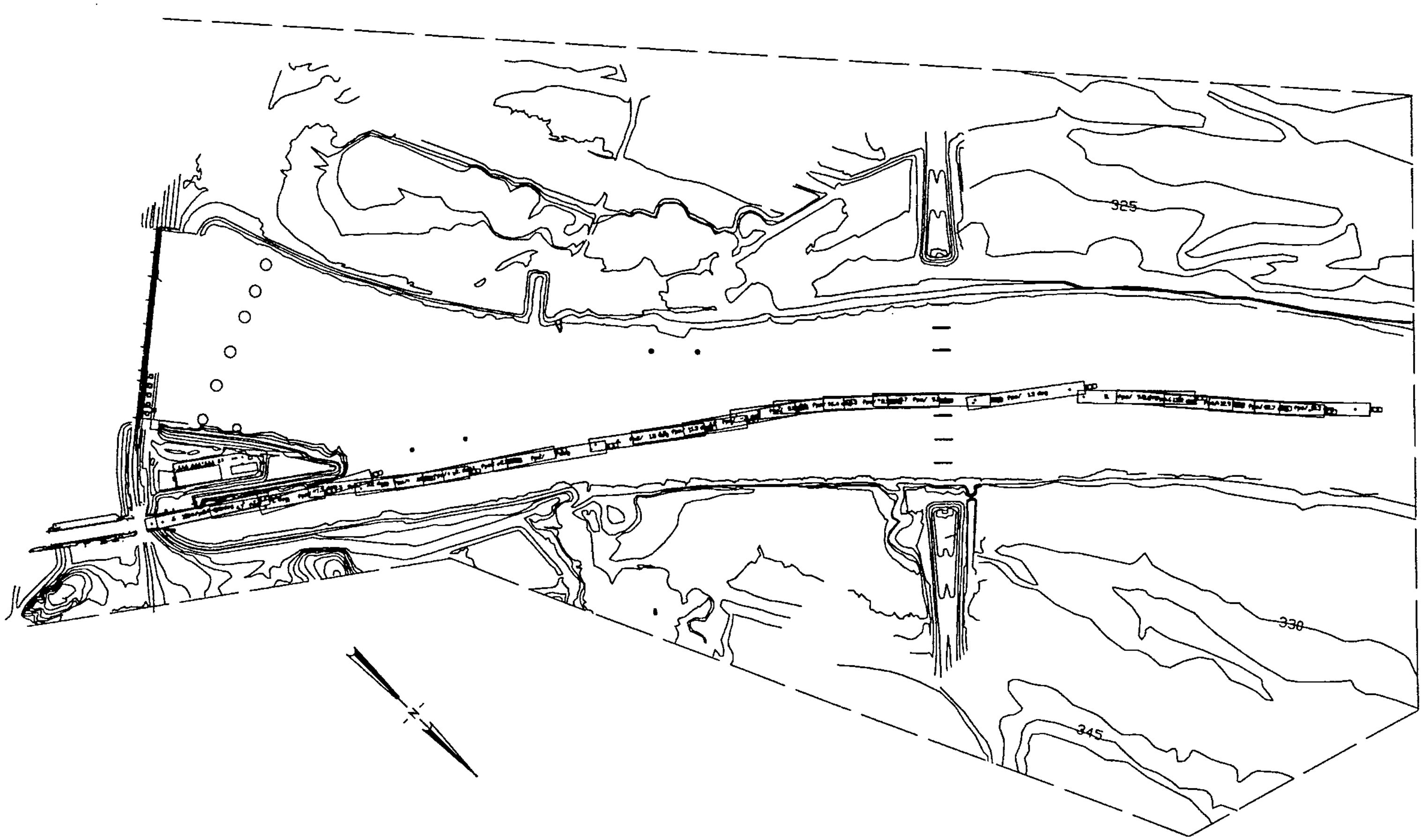
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS, DOWNBOUND

BASE CONDITIONS

DISCHARGE:	370,000	CFS
UPPER POOL EL:	368.3	FT
LOWER POOL EL:	344.0	FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

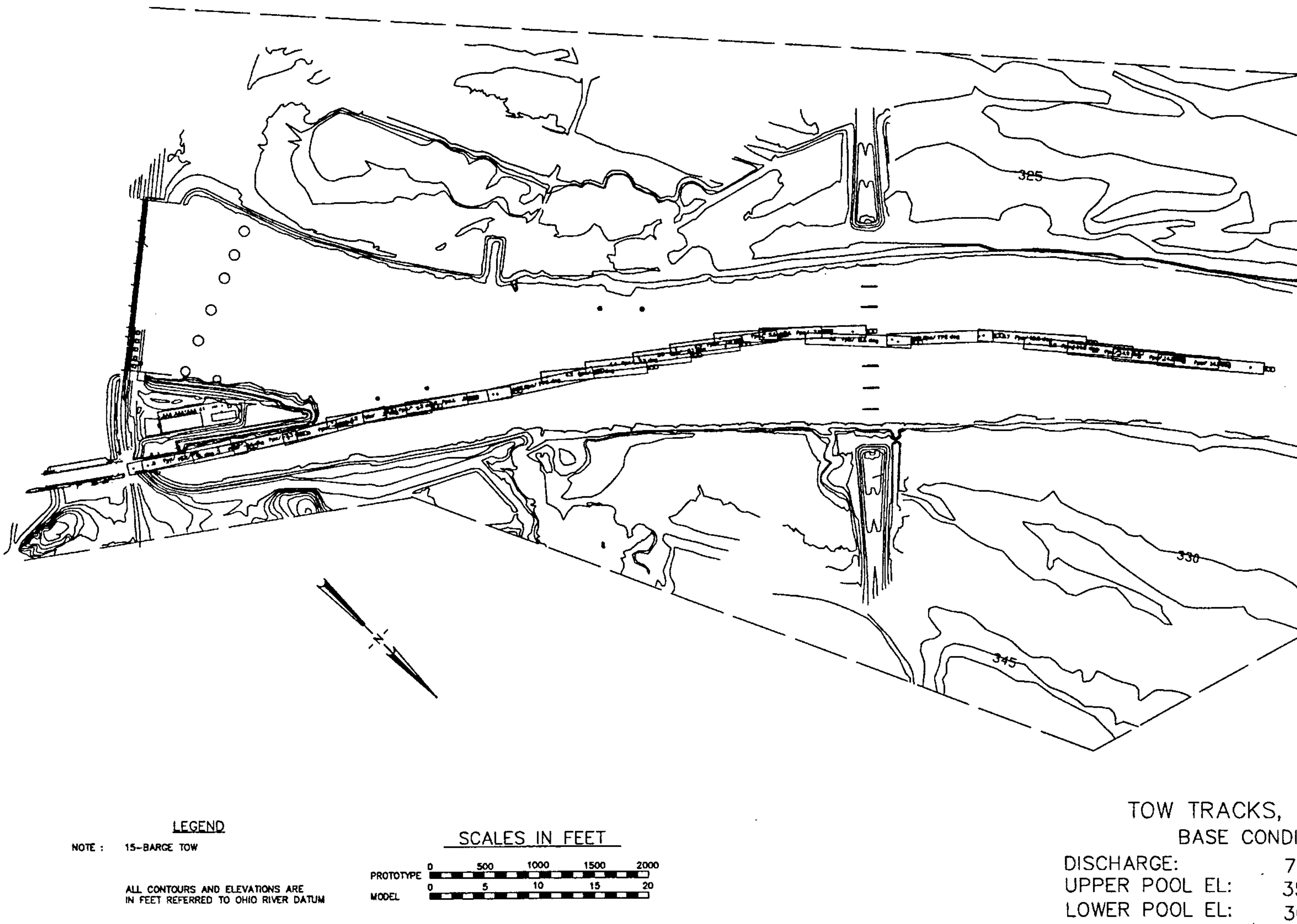
SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

TOW TRACKS, UPBOUND
BASE CONDITIONS

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT

Plate 12



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

TOW TRACKS, UPBOUND
BASE CONDITIONS

DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT

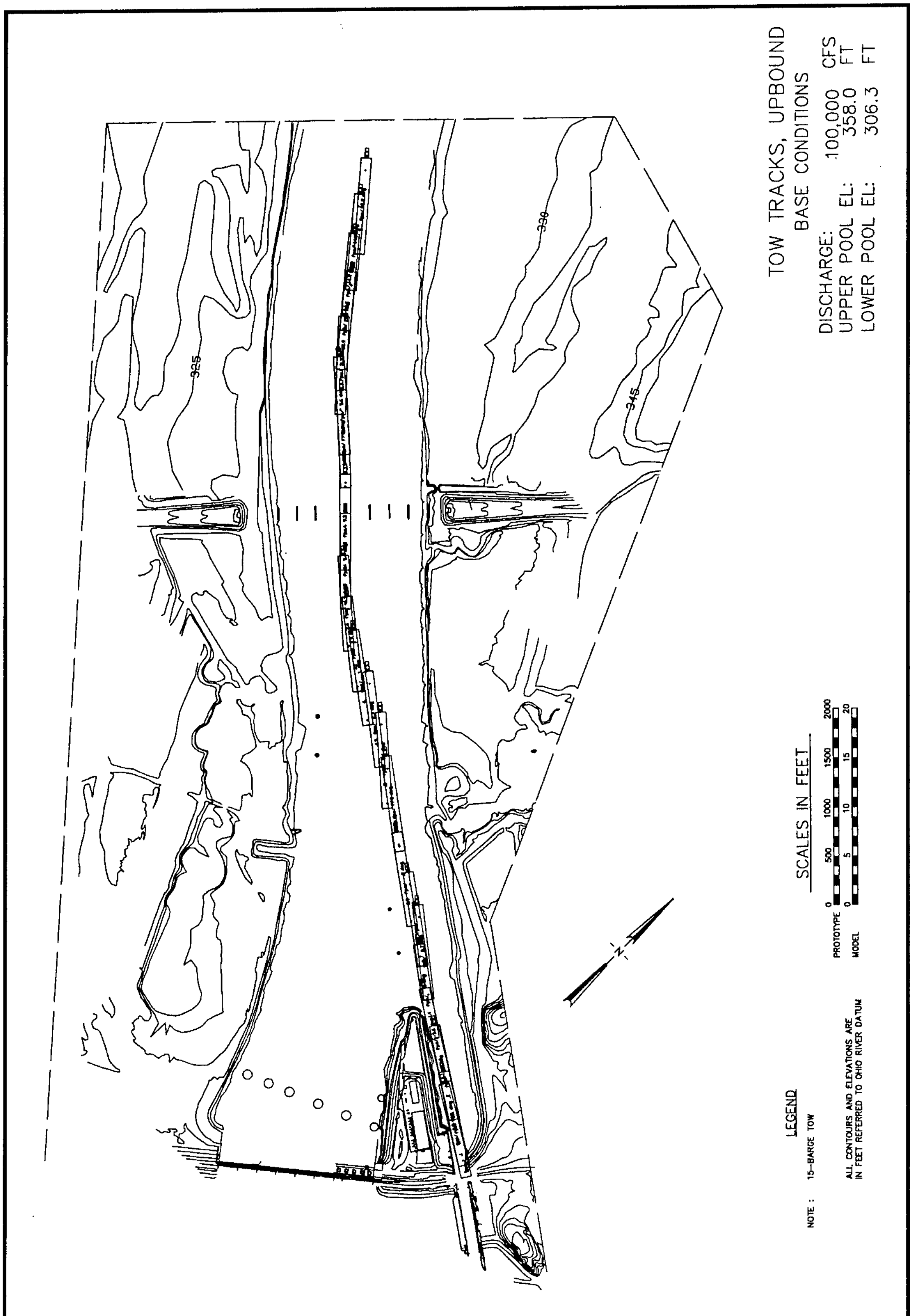
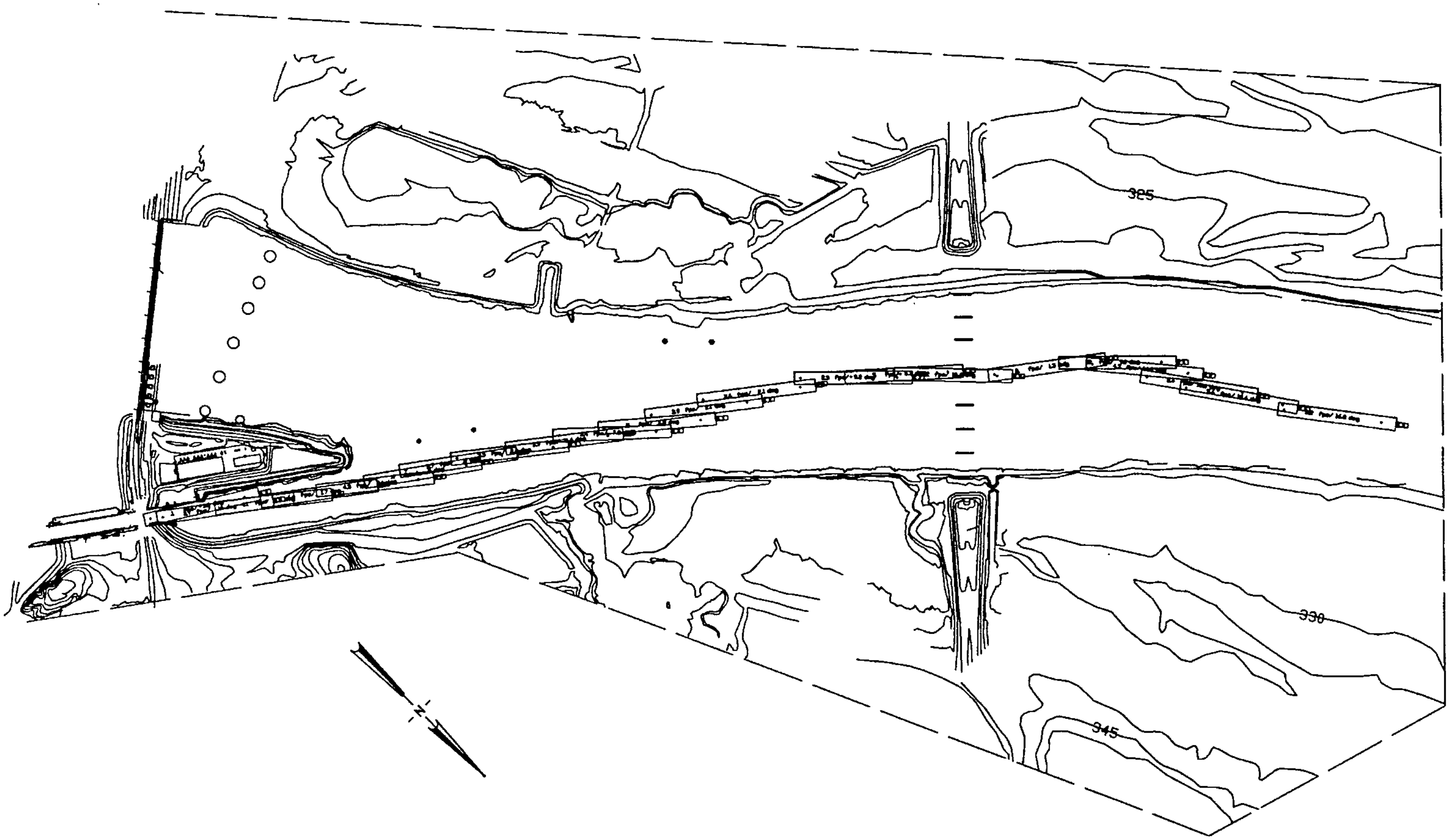

TOW TRACKS, UPBOUND
BASE CONDITIONS
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE: 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N

Plate 14



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

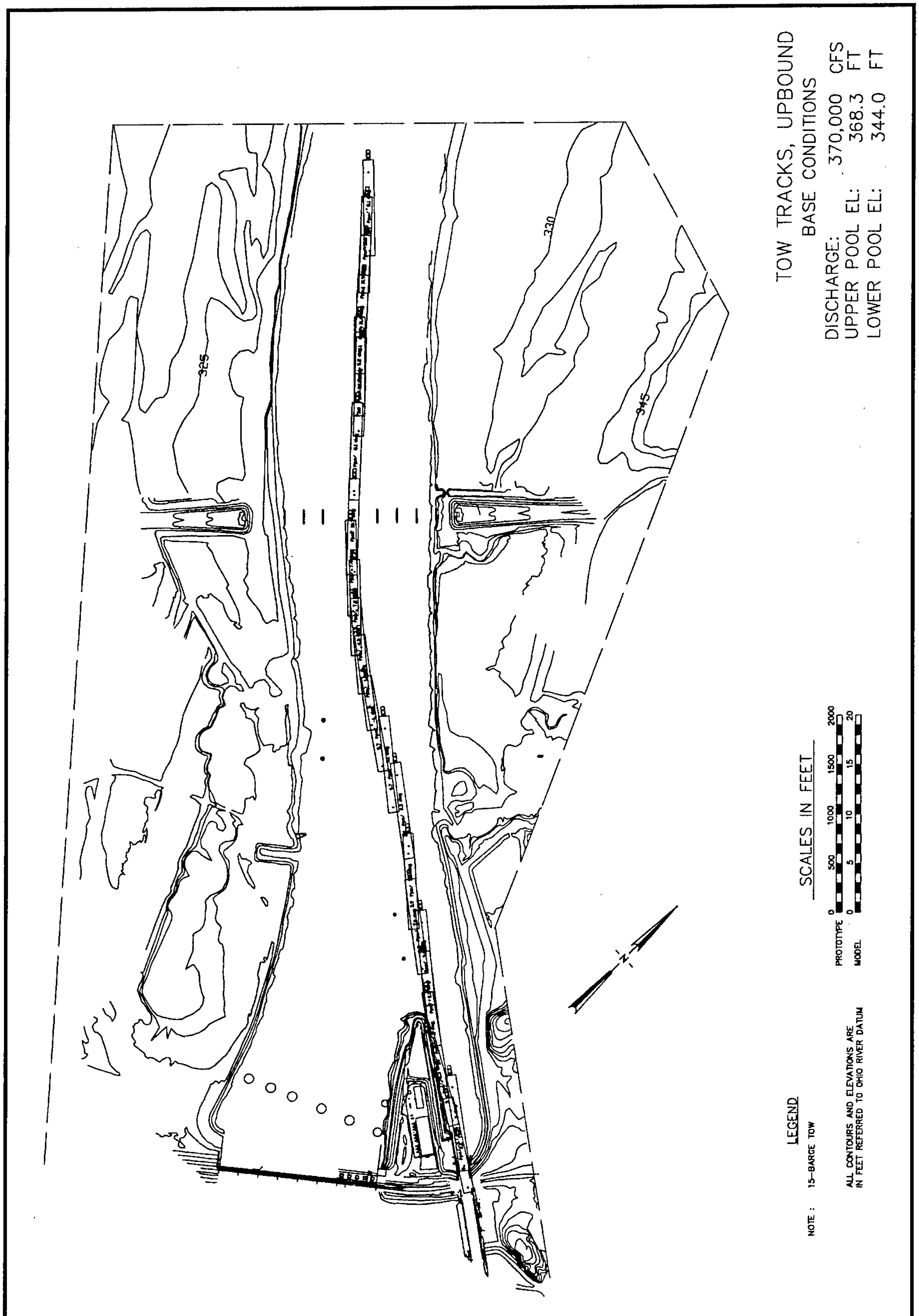
SCALES IN FEET

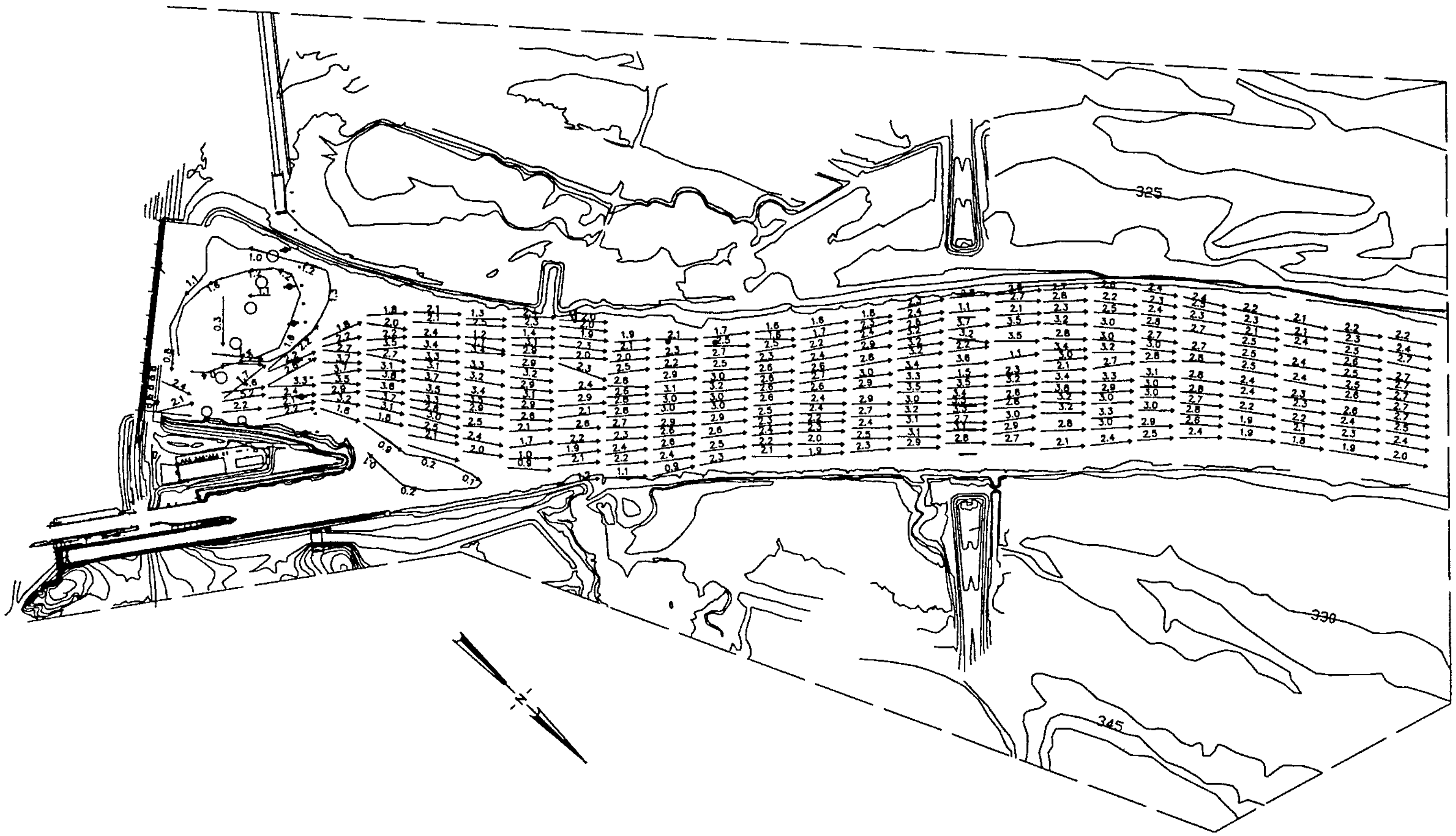
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS, UPBOUND
BASE CONDITIONS

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT


TOW TRACKS, UPBOUND
BASE CONDITIONS
DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT
325
330
345
N
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE: 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



VELOCITIES AND
CURRENT DIRECTIONS
PLAN B

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT

LEGEND

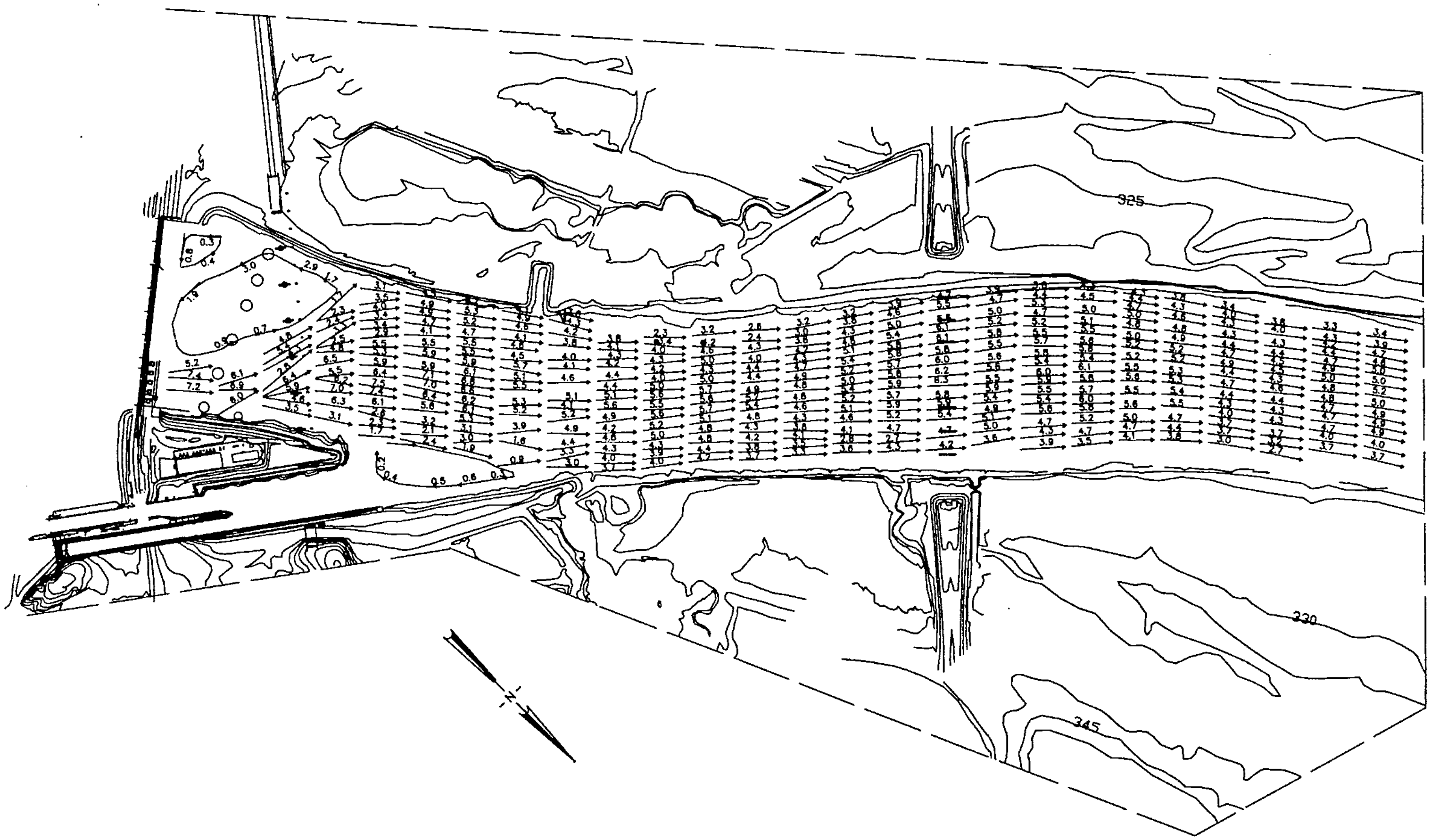
2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

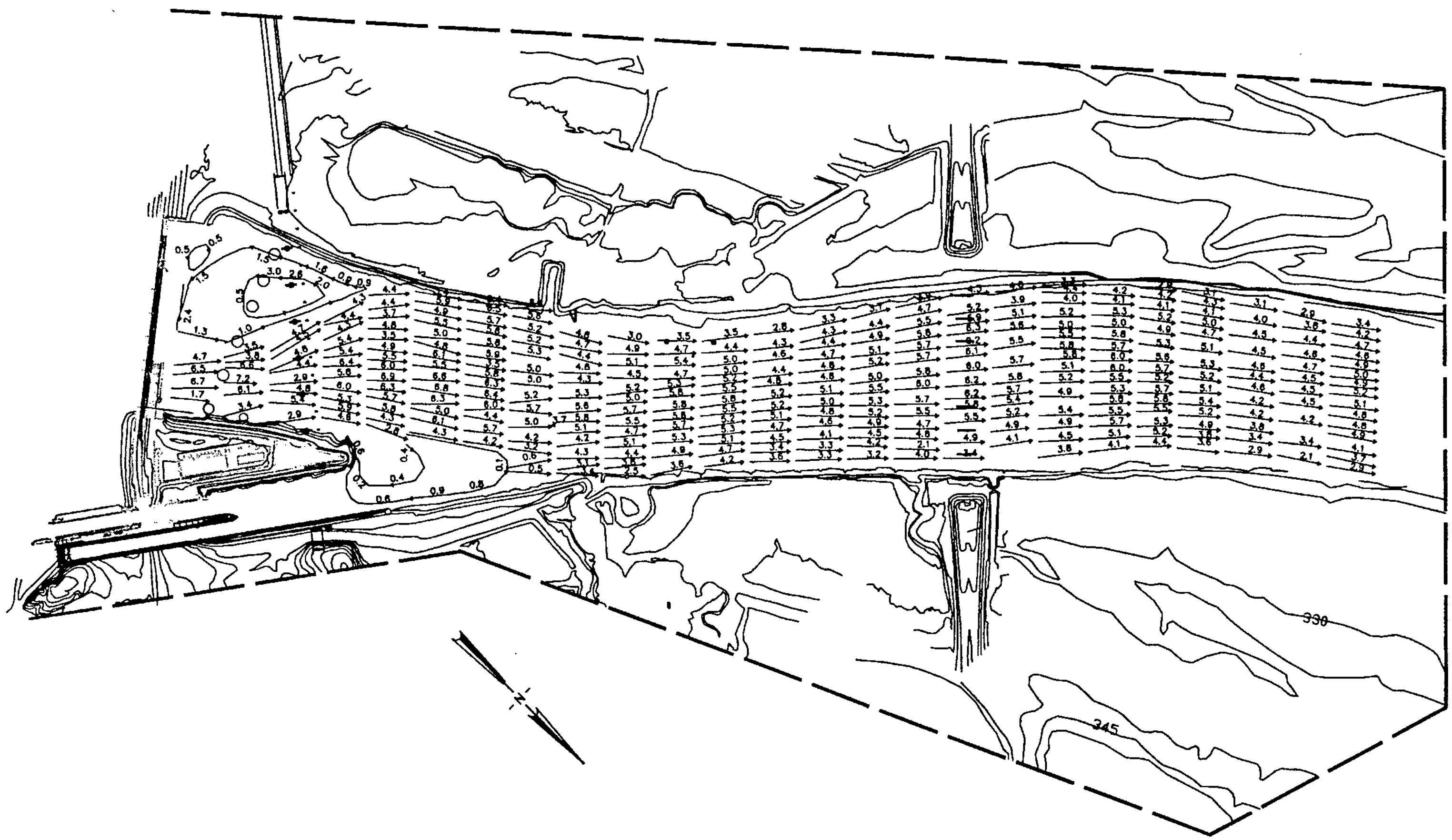
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

VELOCITIES AND
CURRENT DIRECTIONS
PLAN B

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT

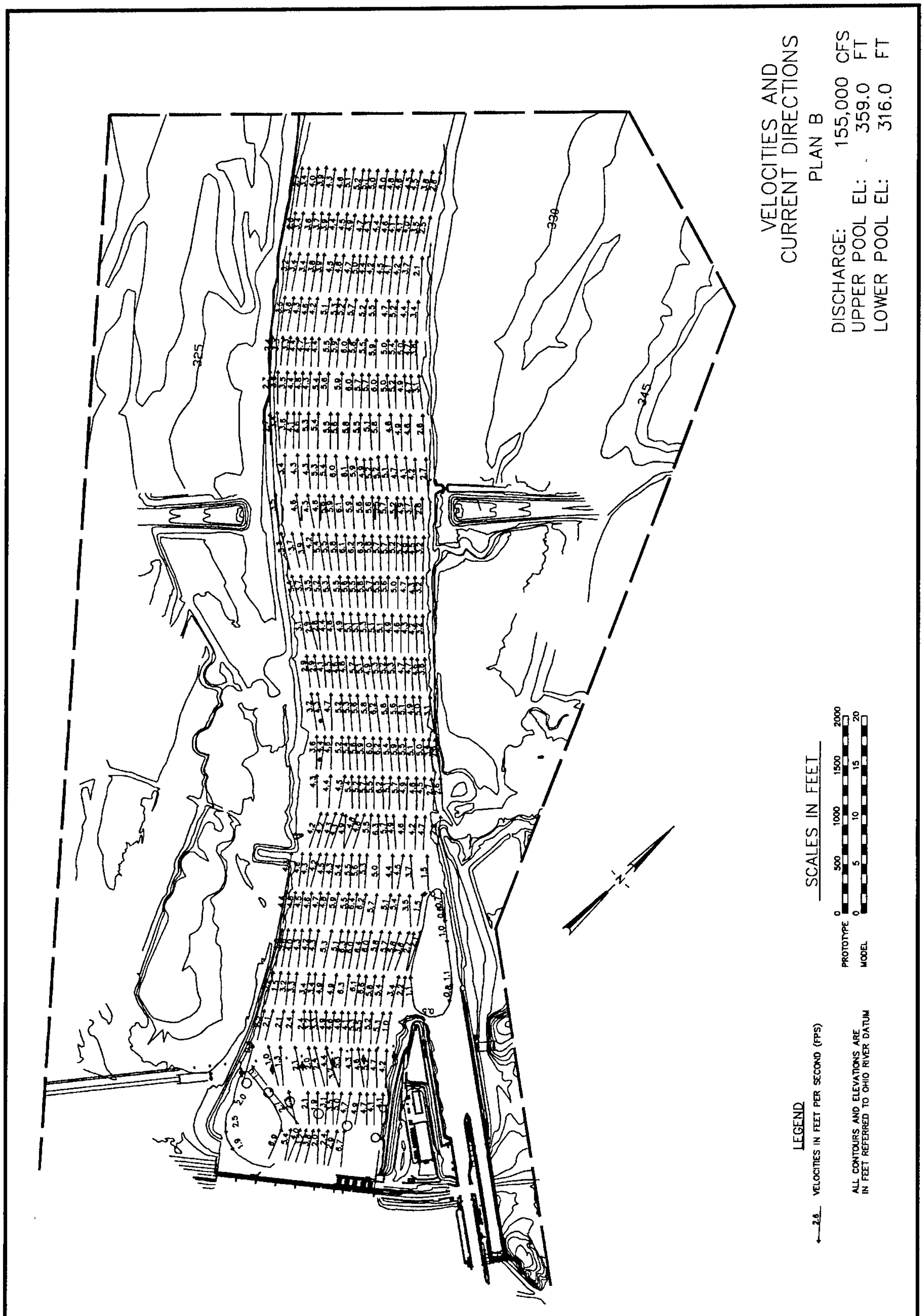
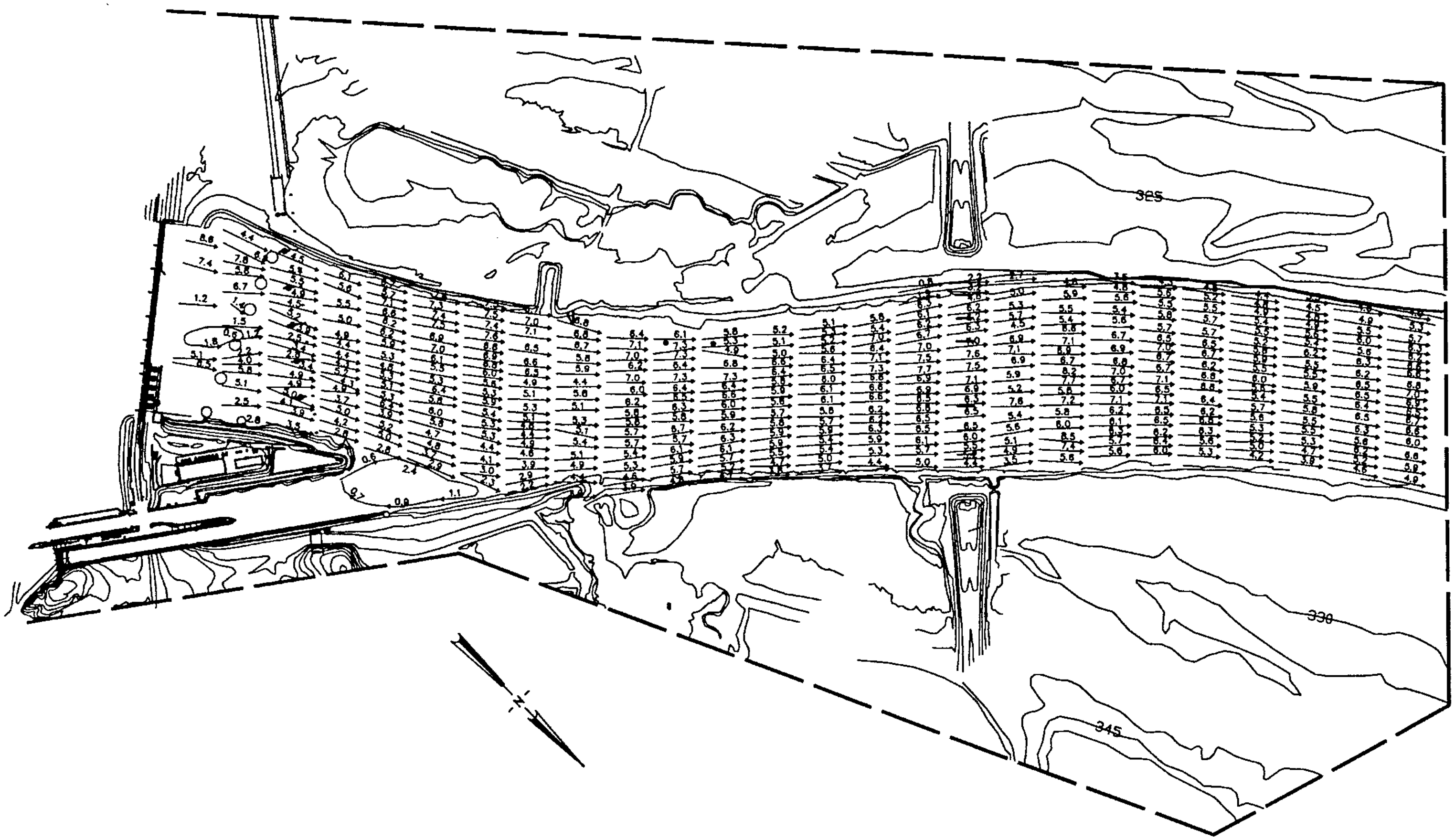

VELOCITIES AND
CURRENT DIRECTIONS
PLAN B
DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT
LEGEND
2.6 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
325
330
345

Plate 20



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

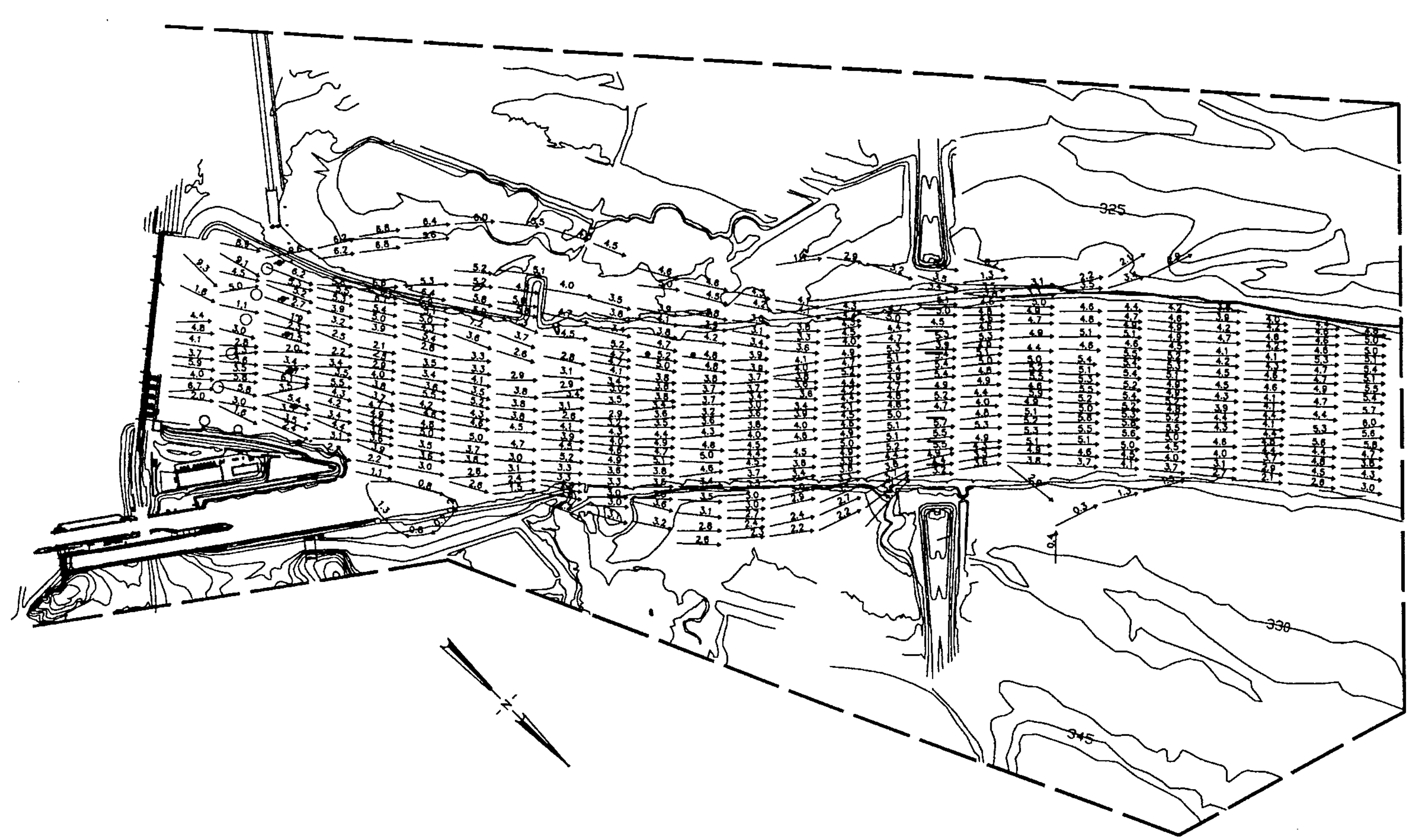
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



VELOCITIES AND
CURRENT DIRECTIONS

PLAN B

DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT

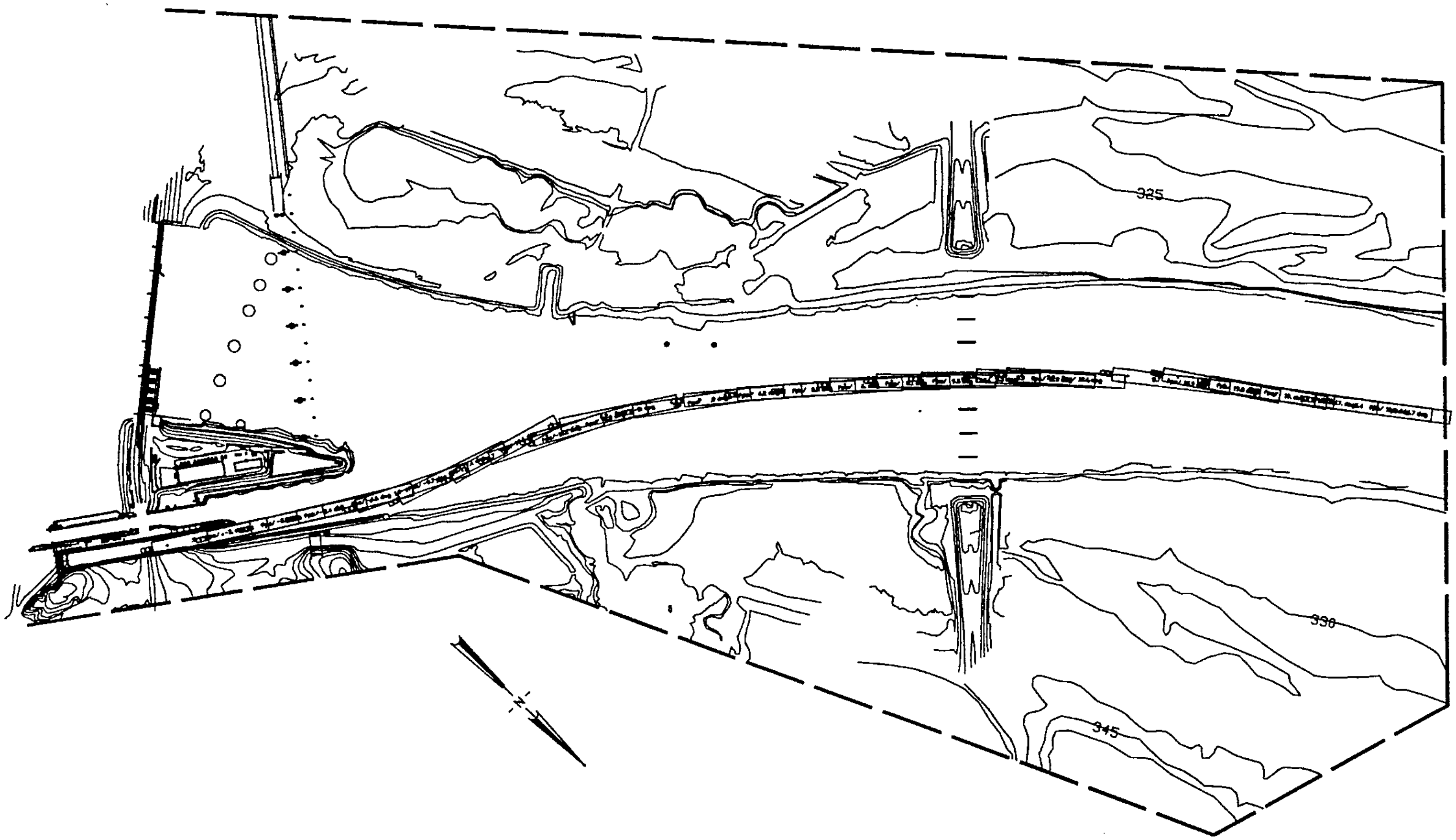
LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

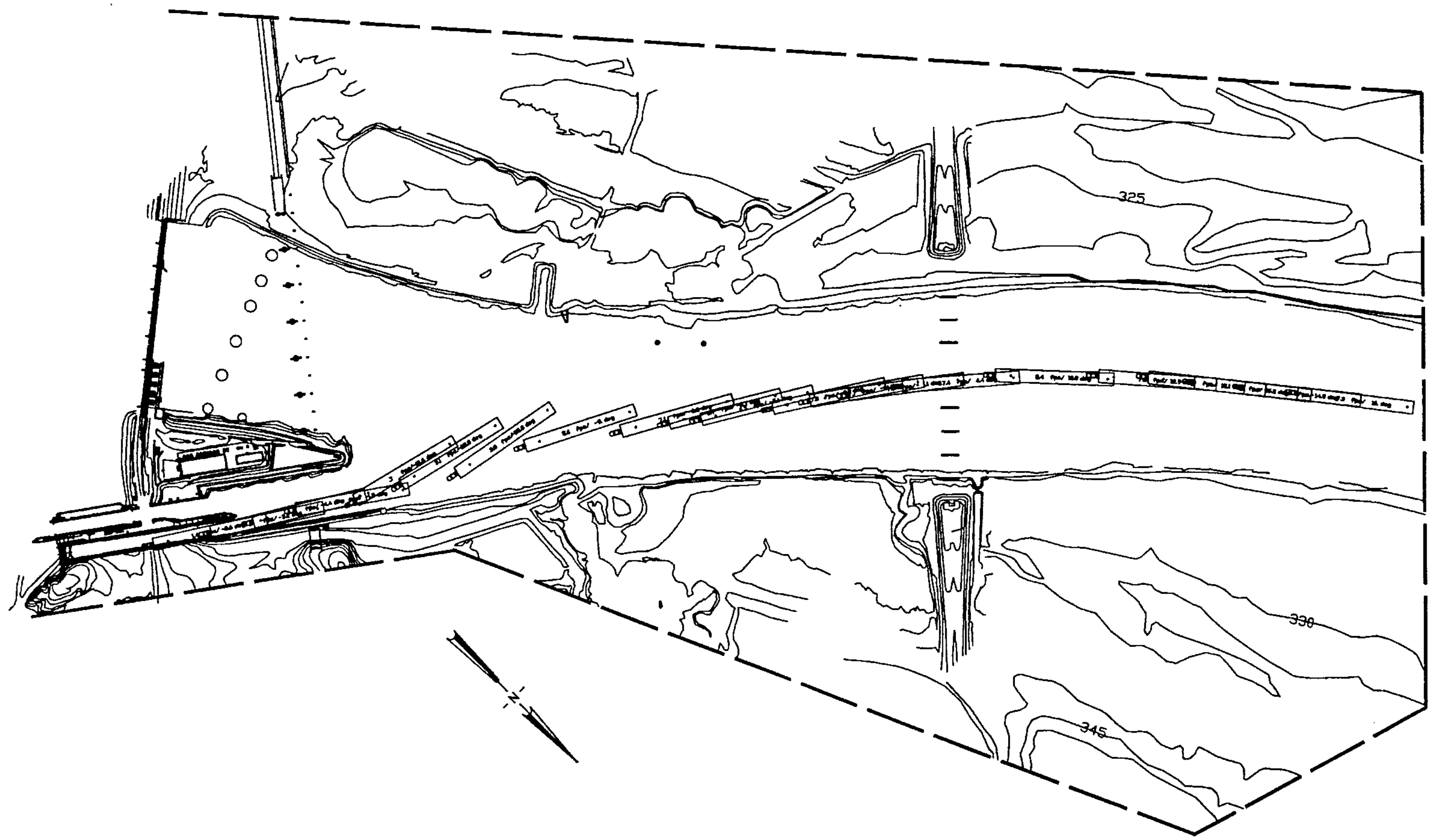
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B, DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

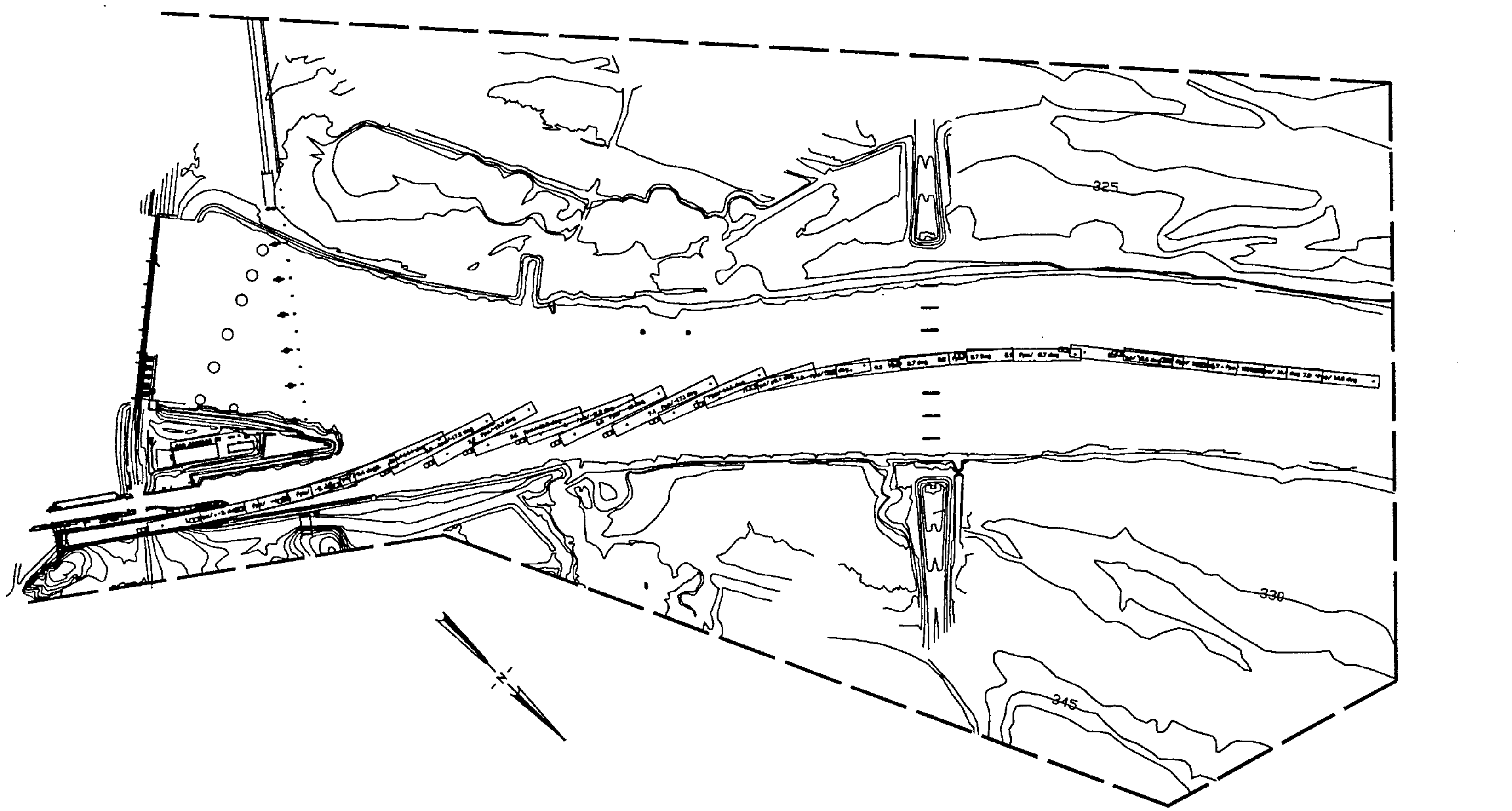
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

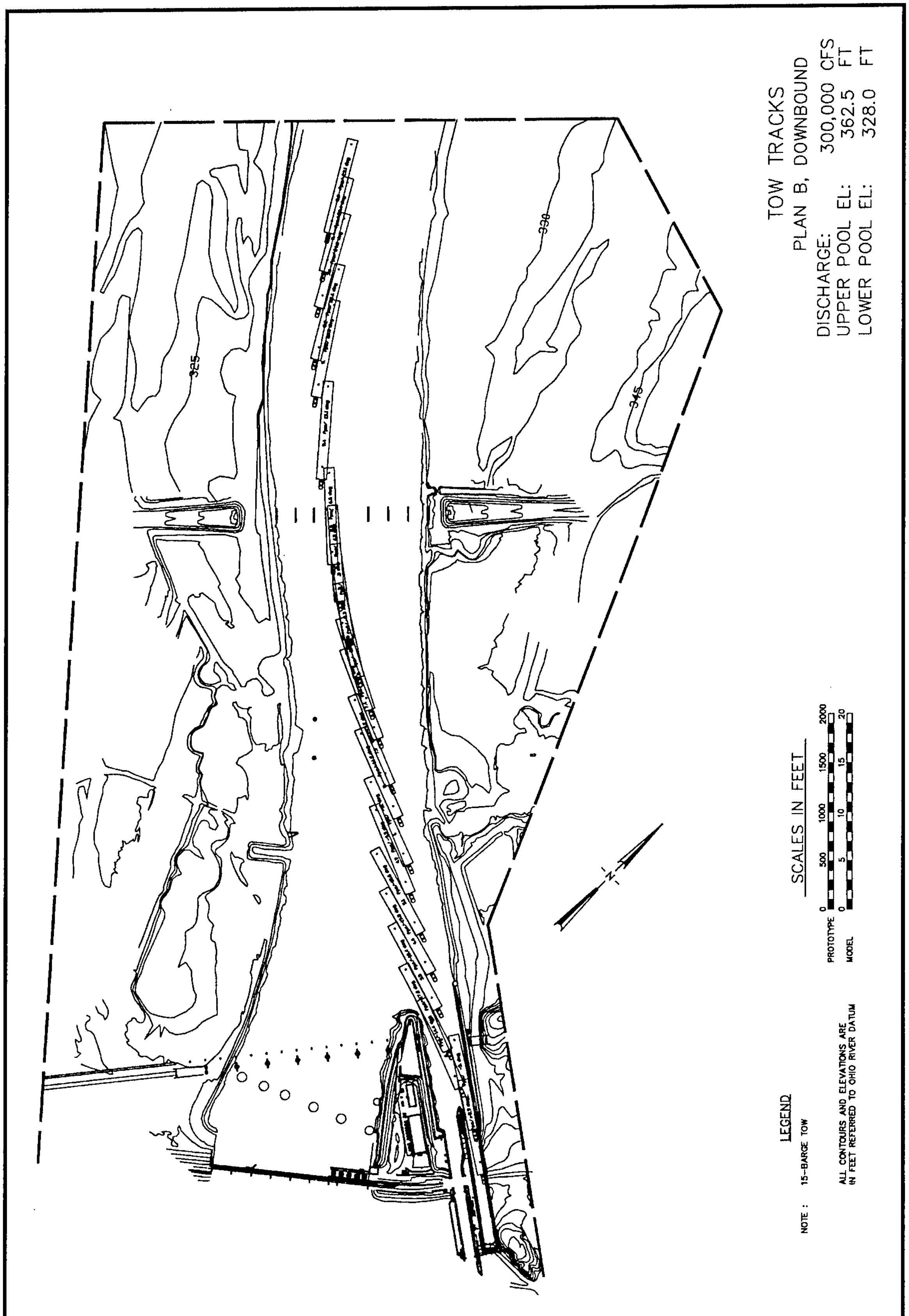
PLAN B, DOWNBOUND

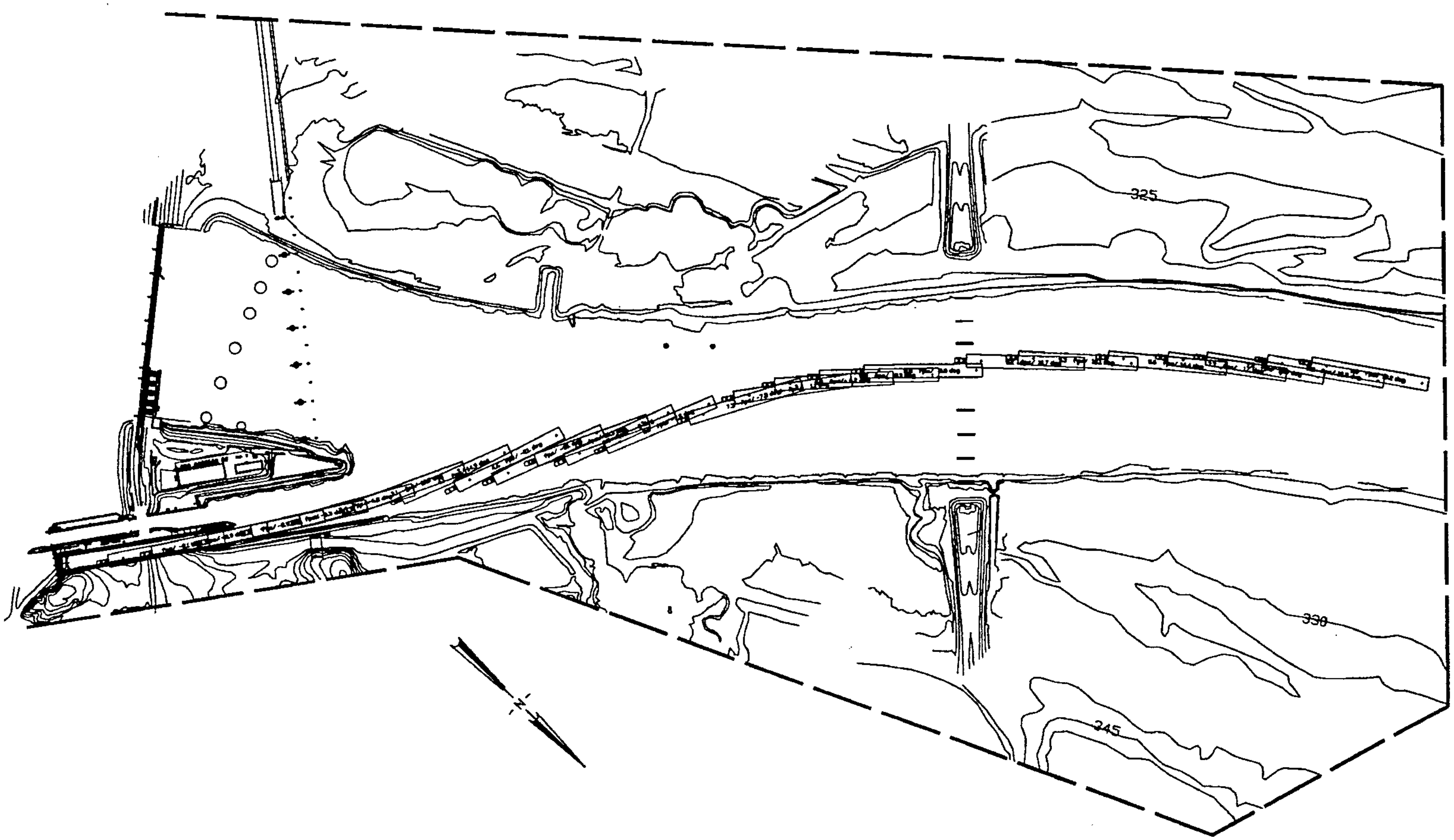
DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



TOW TRACKS
PLAN B, DOWNBOUND

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 303.6 FT


TOW TRACKS
PLAN B, DOWNBOUND
DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE : ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N



LEGEND

NOTE : 15-BARGE TOW

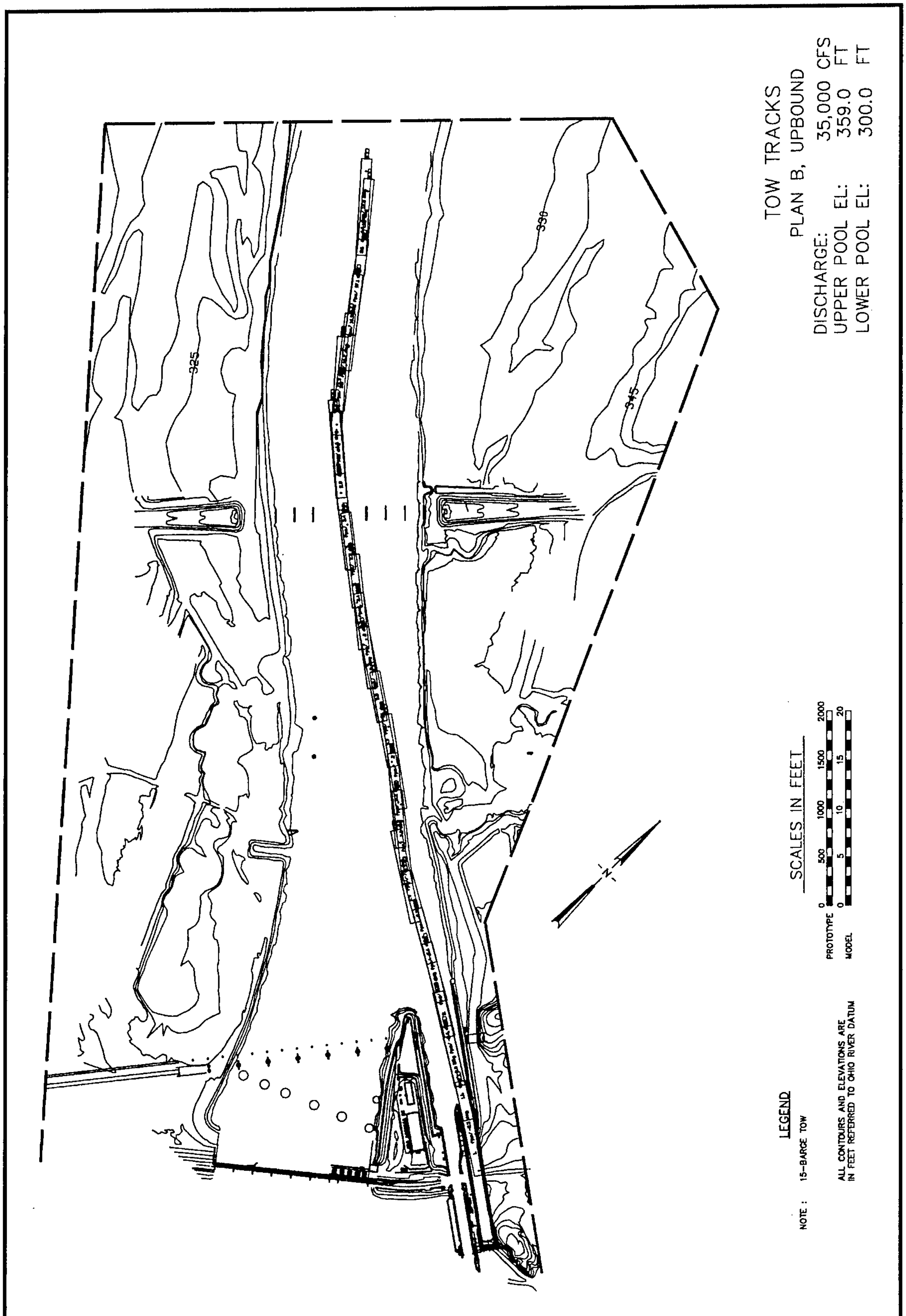
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

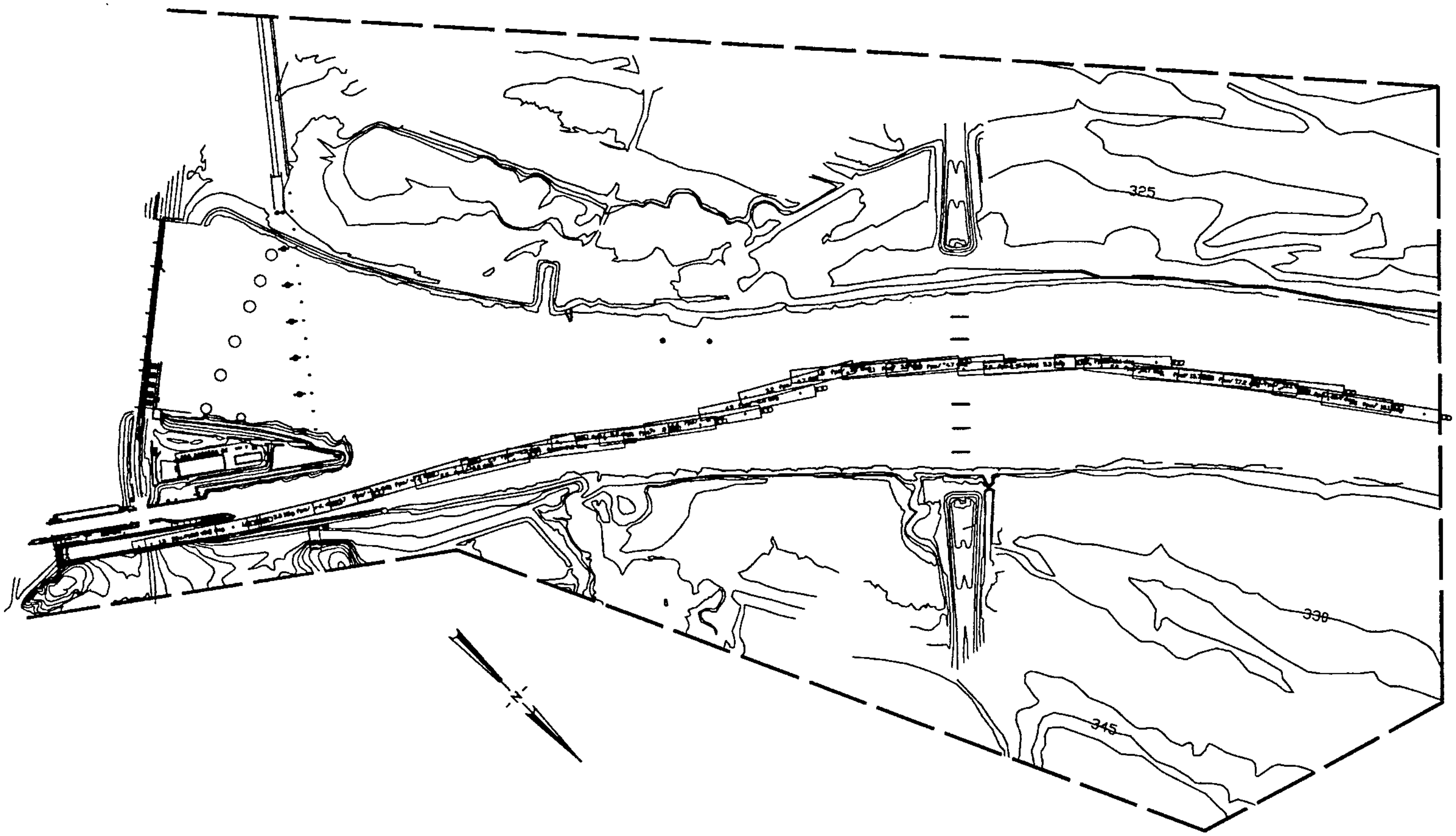
TOW TRACKS
PLAN B, DOWNBOUND

DISCHARGE:	370,000	CFS
UPPER POOL EL:	368.3	FT
LOWER POOL EL:	344.0	FT



TOW TRACKS
PLAN B, UPBOUND
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
325
330
345
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

Plate 28



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B, UPOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT

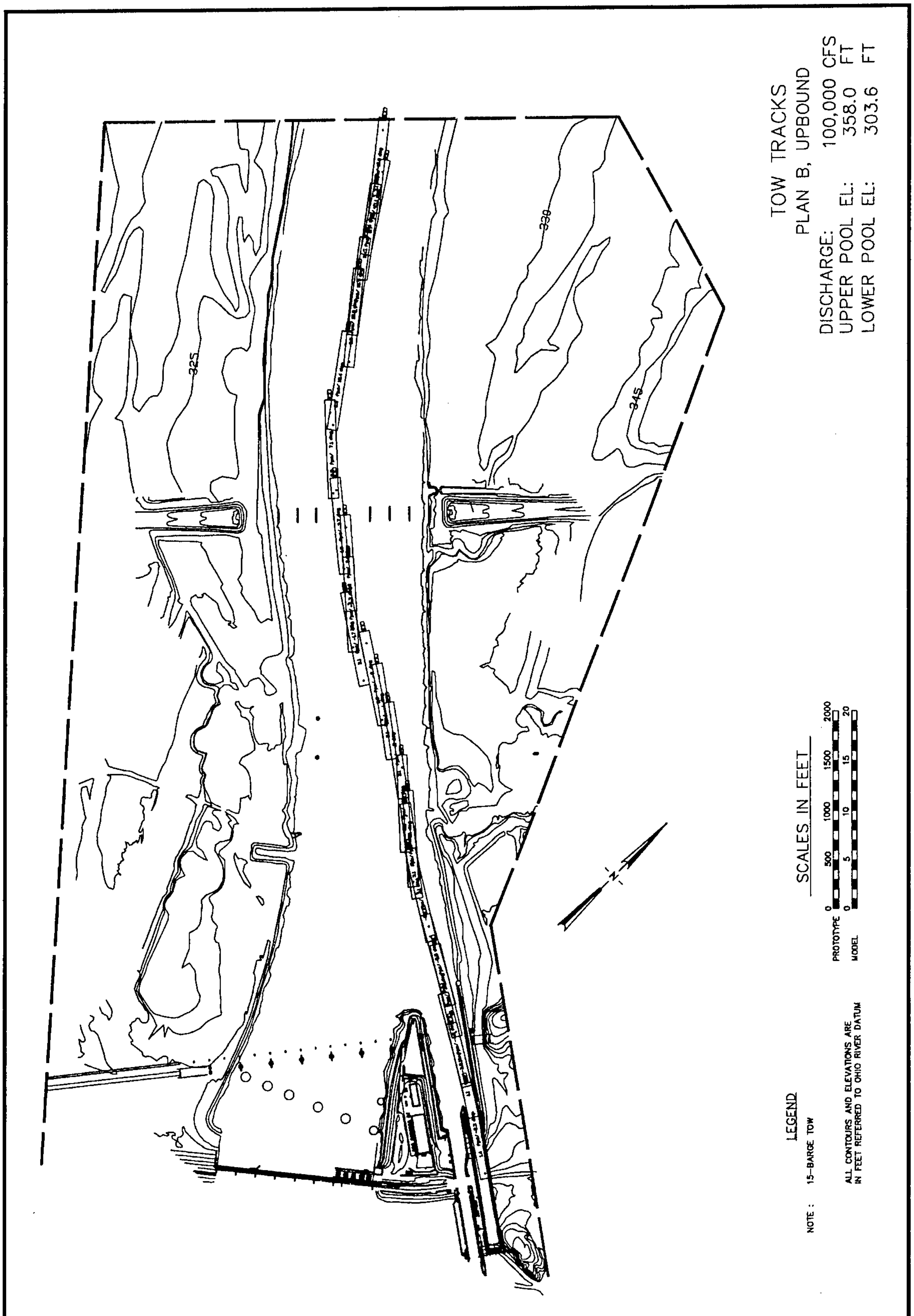
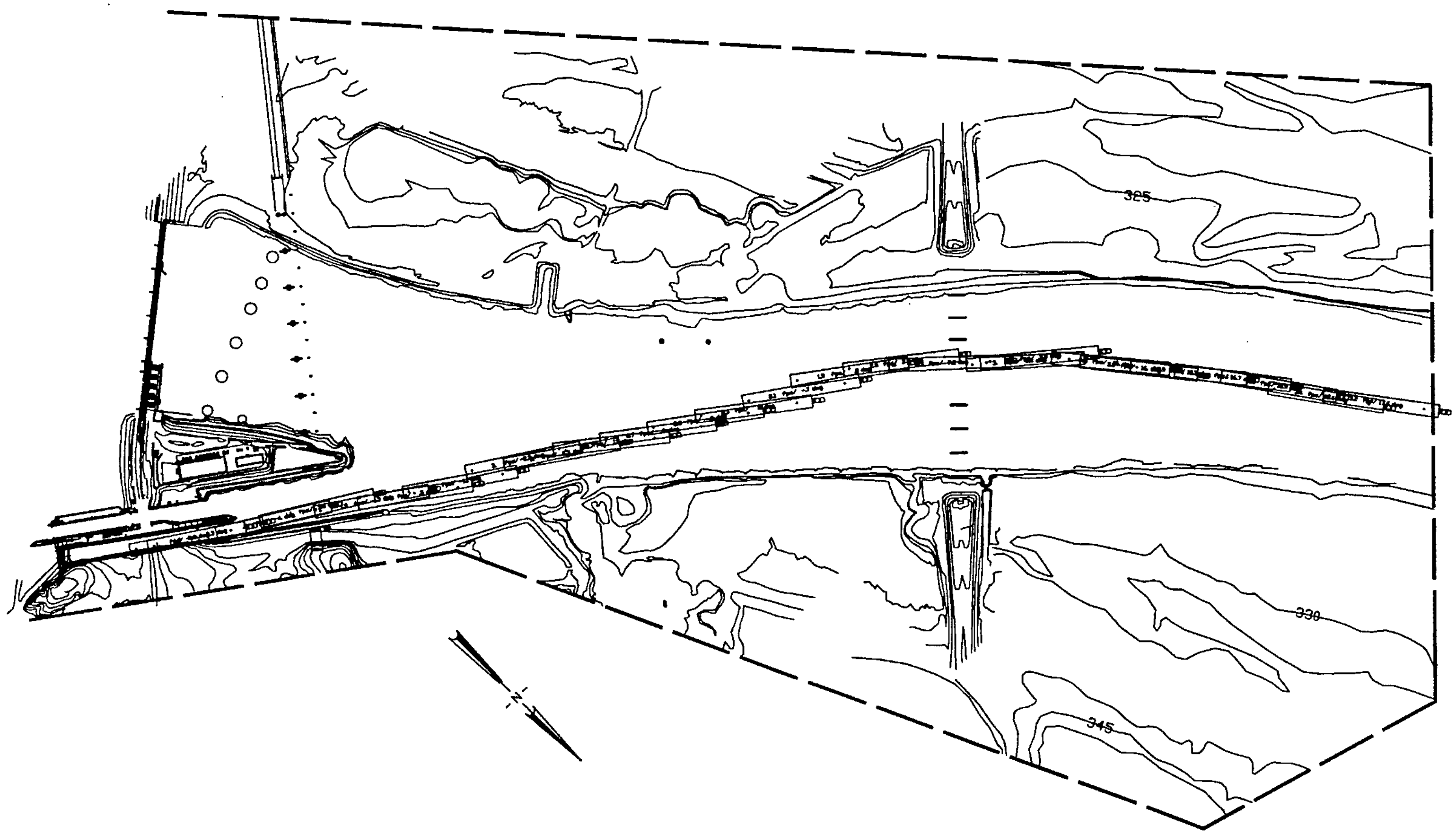

TOW TRACKS
PLAN B, UPBOUND
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 303.6 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
338
345

Plate 30



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

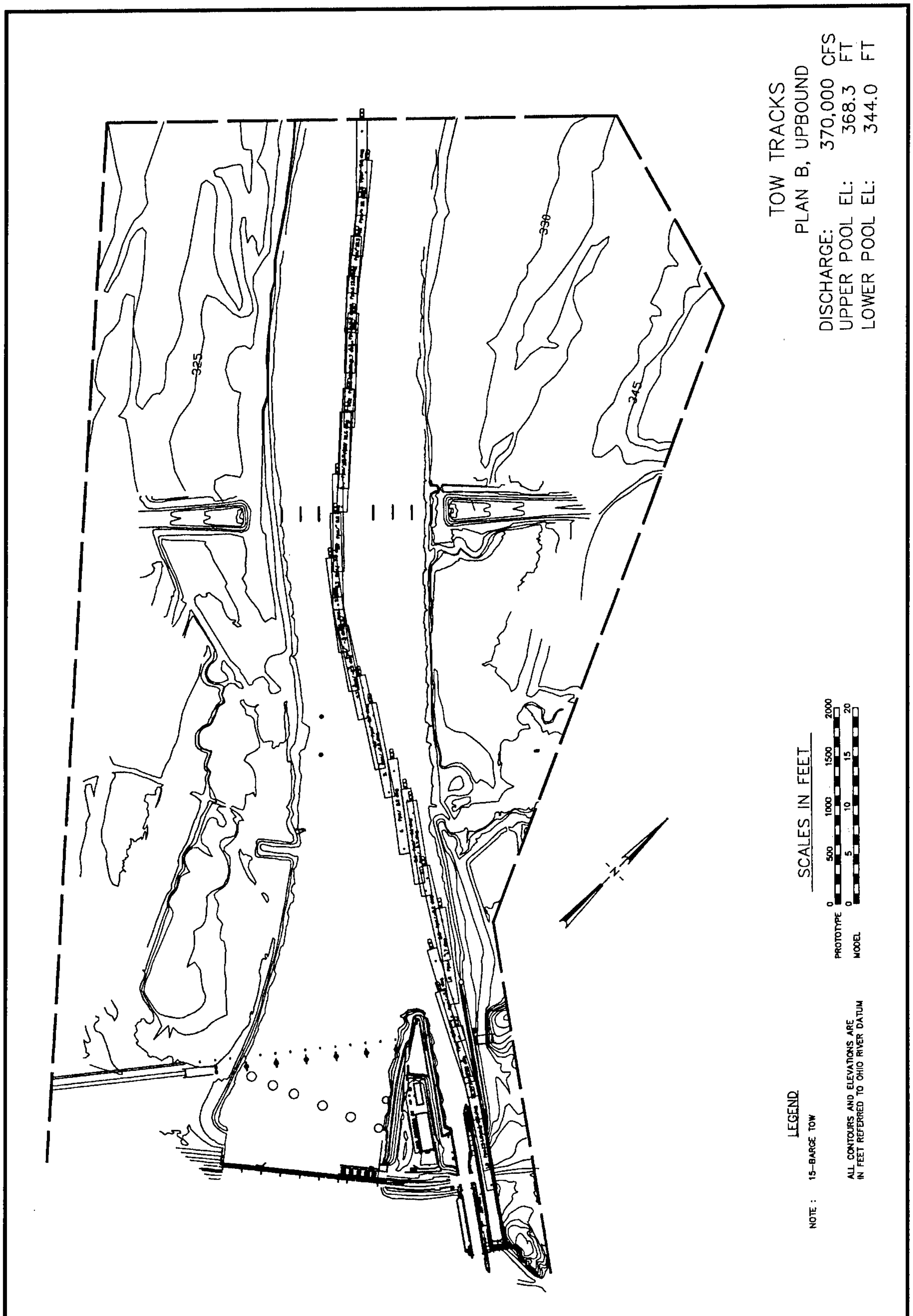
PLAN B, UPBOUND

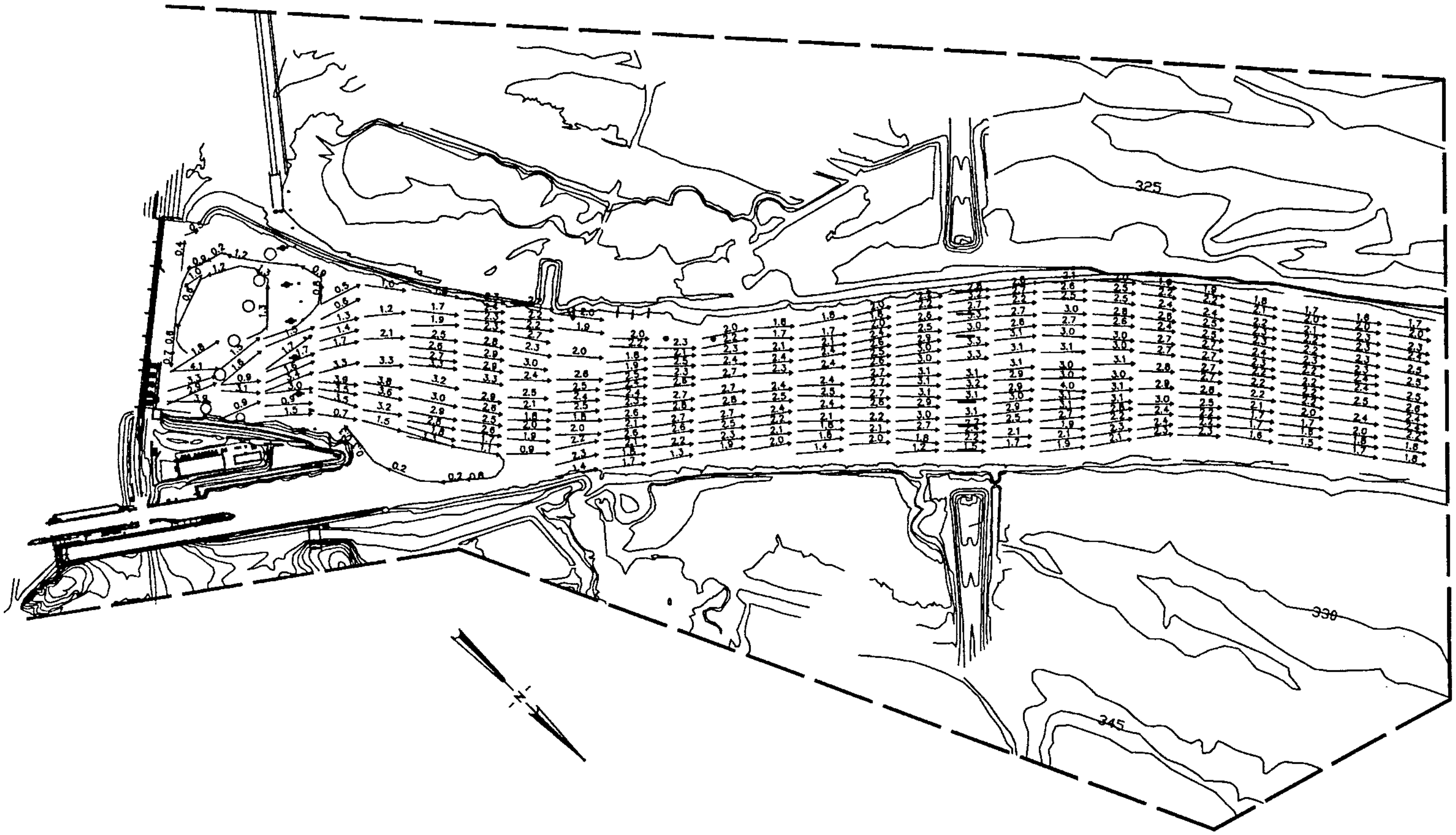
DISCHARGE: 300,000 CFS

UPPER POOL EL: 362.5 FT

LOWER POOL EL: 328.0 FT

Plate 31


TOW TRACKS
PLAN B, UPBOUND
DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345

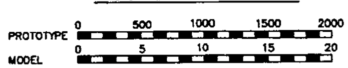


LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

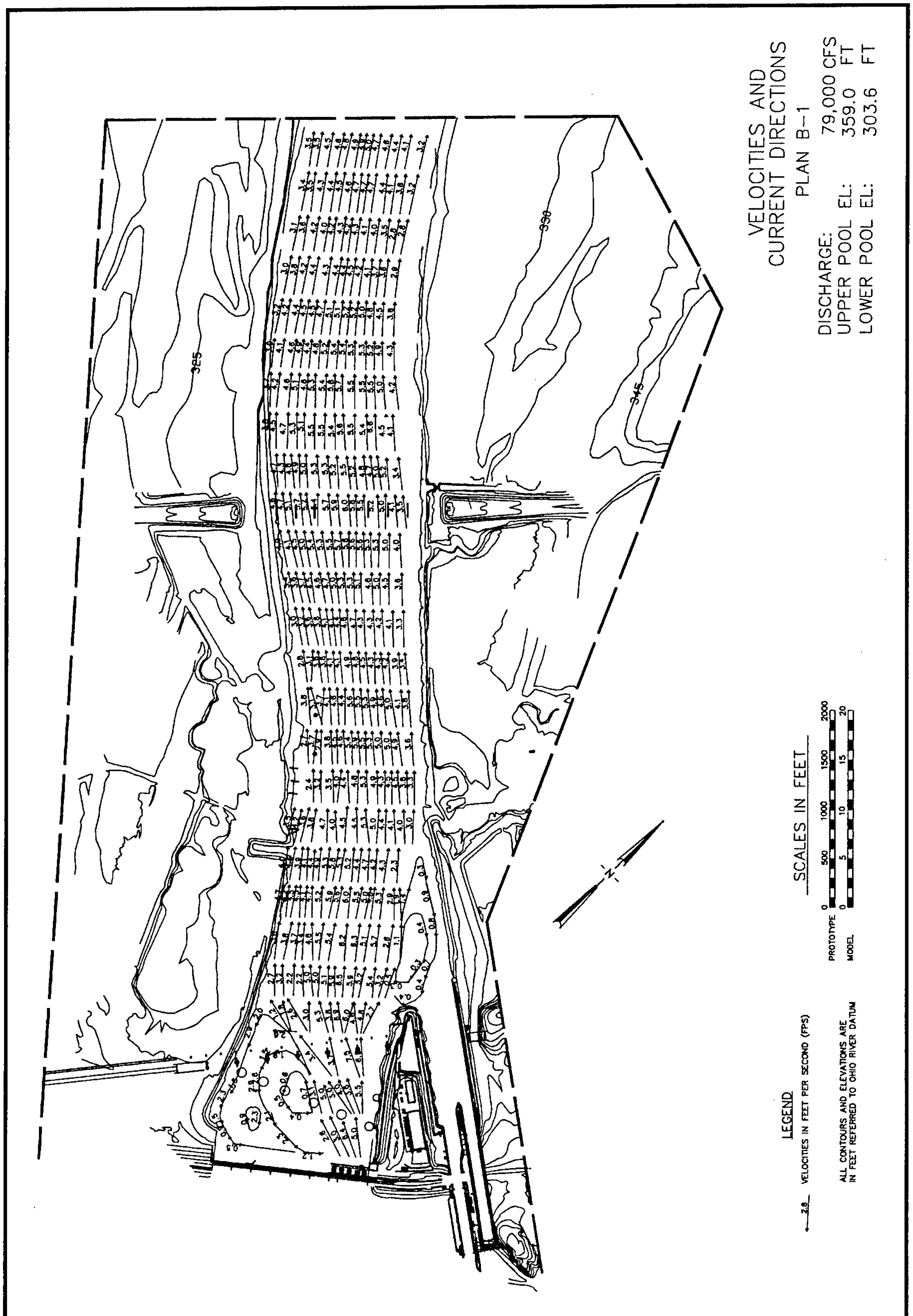
SCALES IN FEET

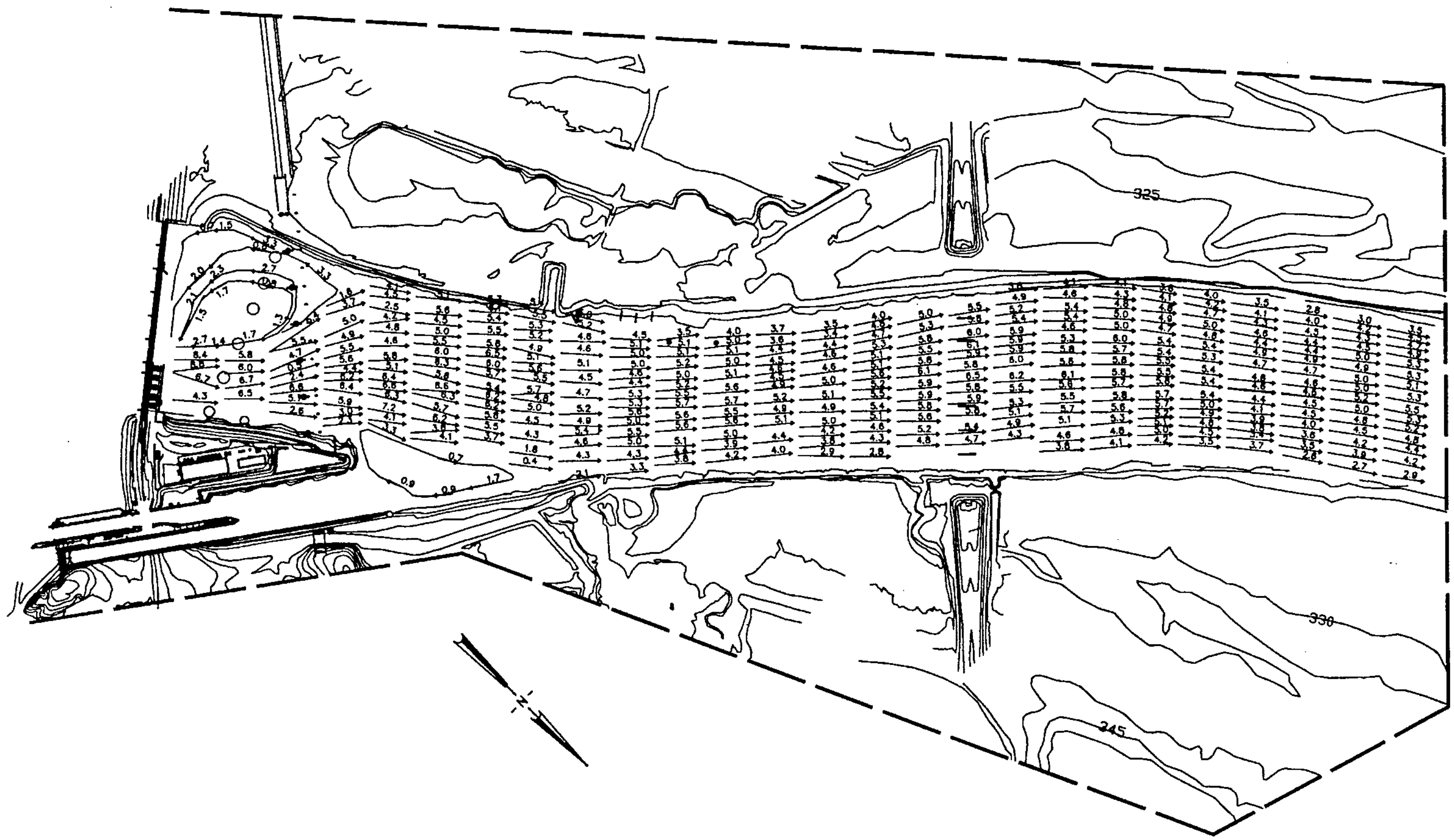


VELOCITIES AND
CURRENT DIRECTIONS

PLAN B-1

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT


VELOCITIES AND
CURRENT DIRECTIONS
PLAN B-1
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

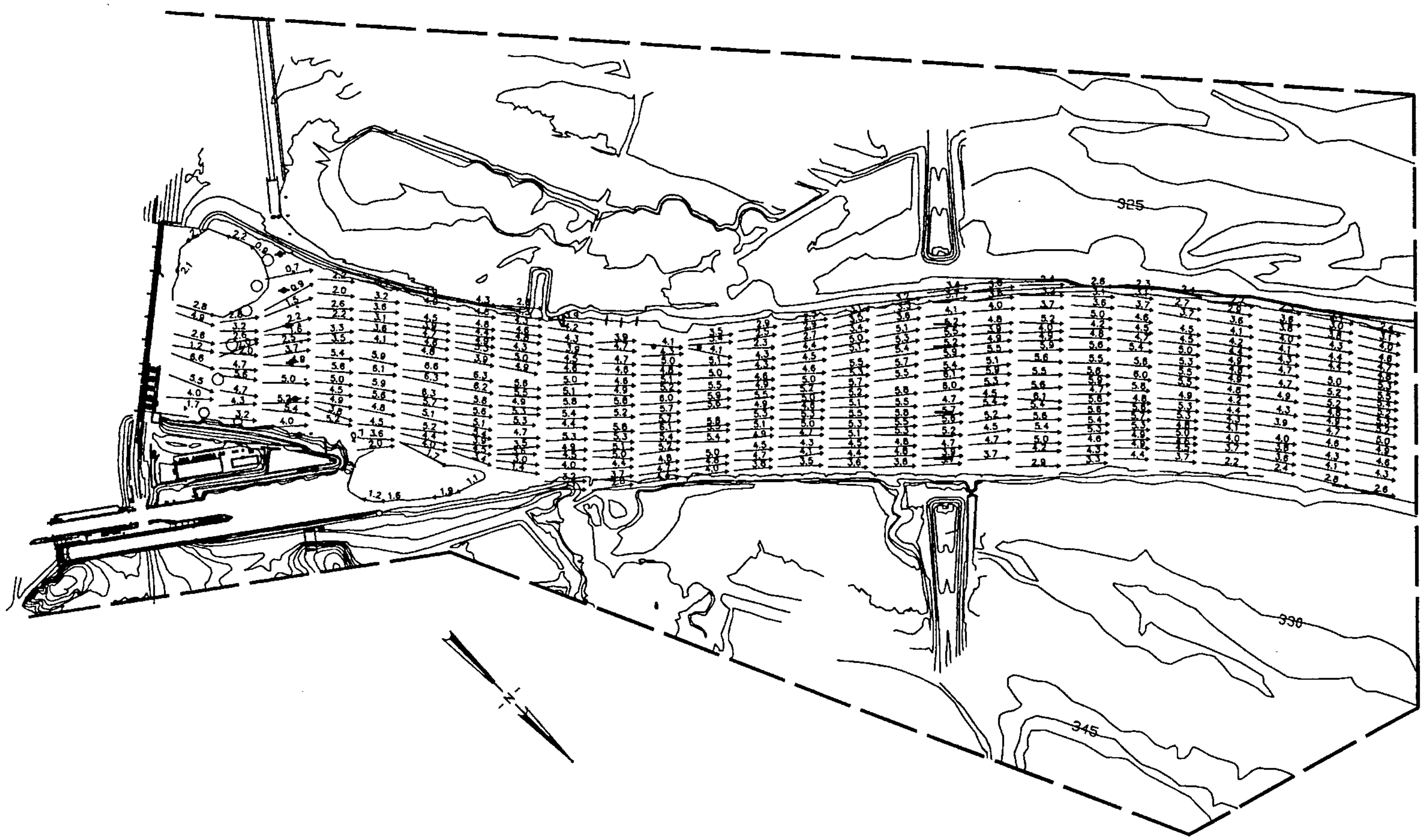
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B–1

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

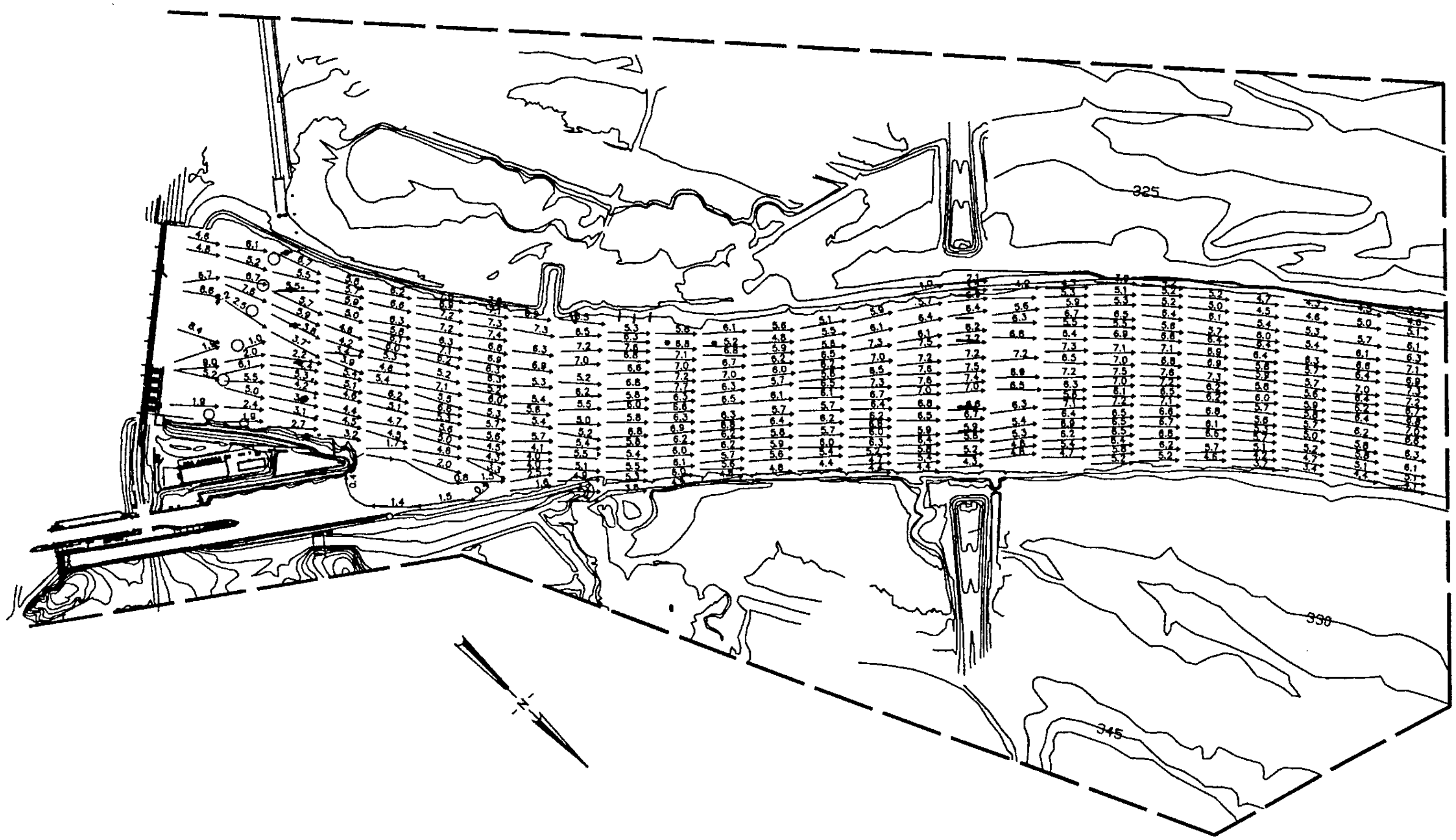
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B–1

DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

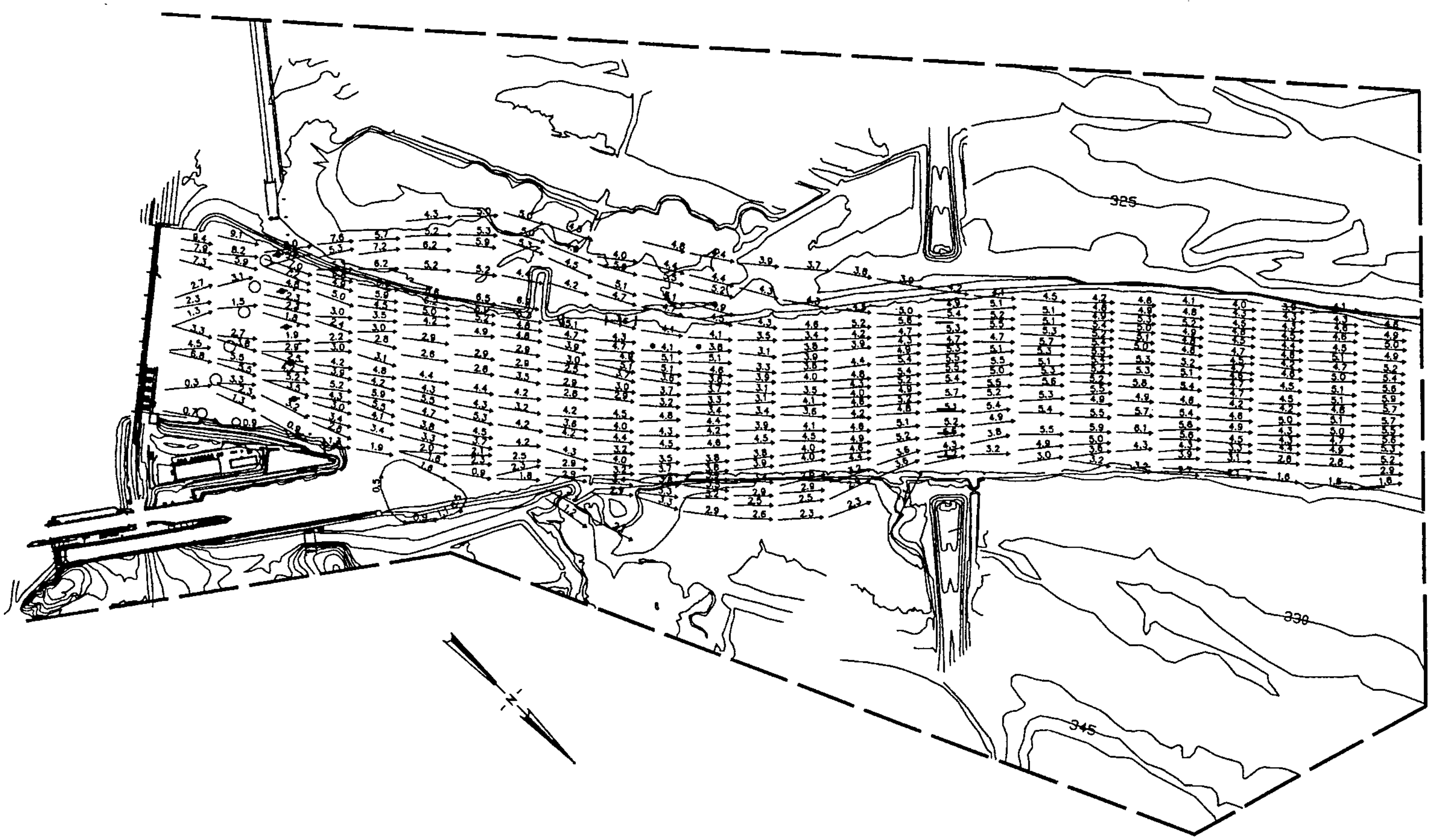
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-1

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

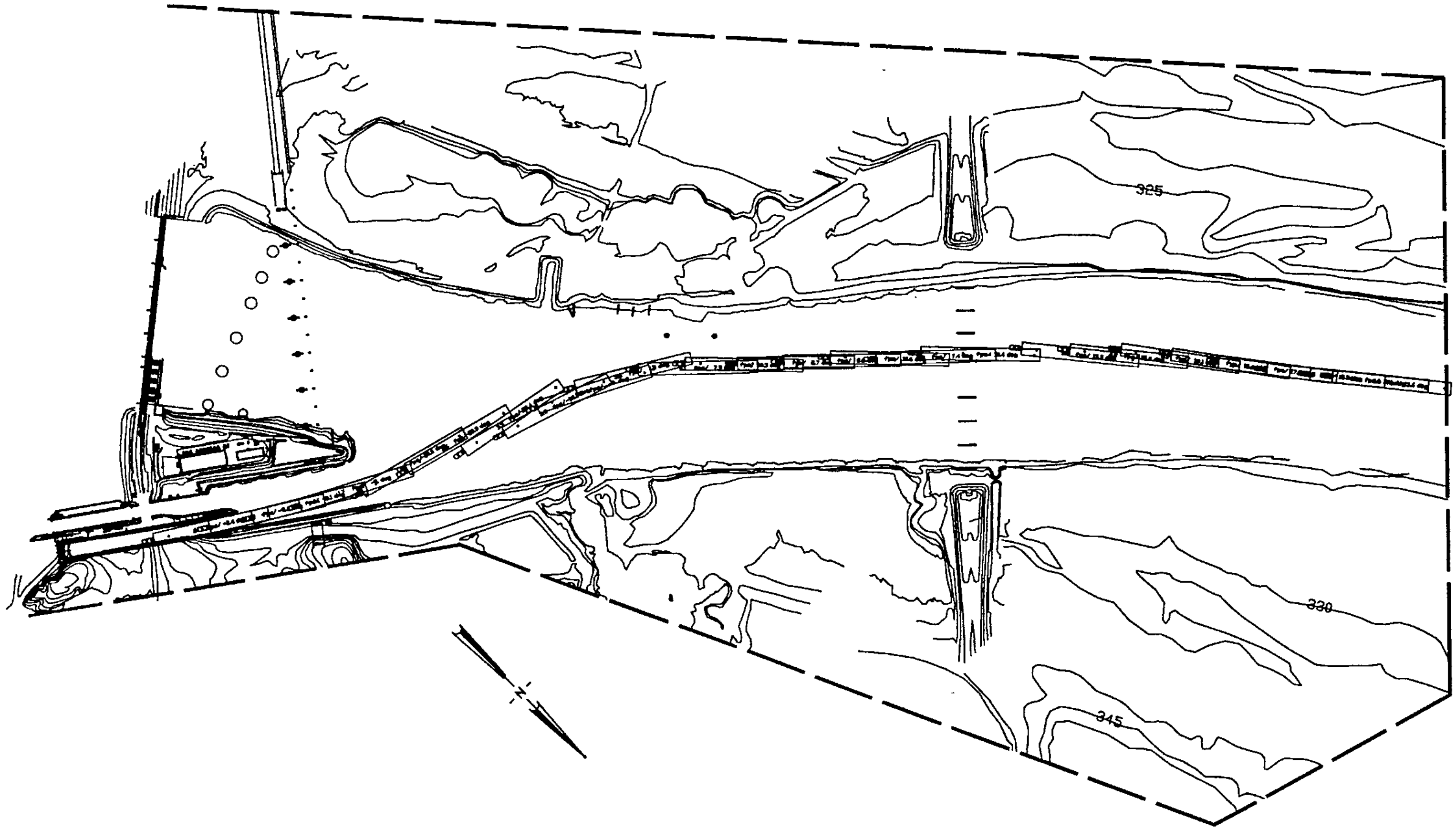
VELOCITIES AND CURRENT DIRECTIONS

PLAN B-1

DISCHARGE: 370,000 CFS

UPPER POOL EL: 368.3 FT

LOWER POOL EL: 344.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

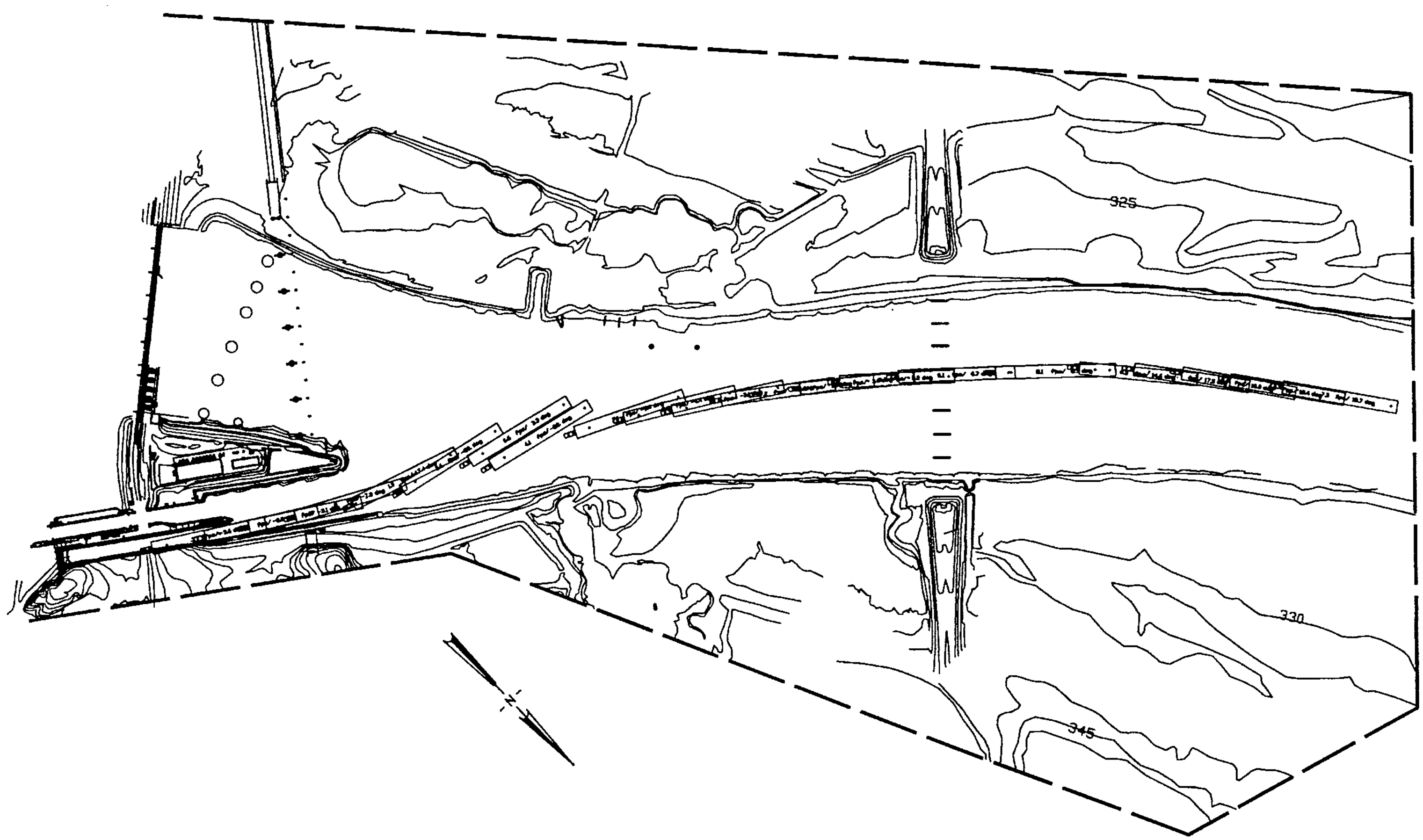
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-1, DOWNBOUND

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT



LEGEND

NOTE : 15-BARGE TOW

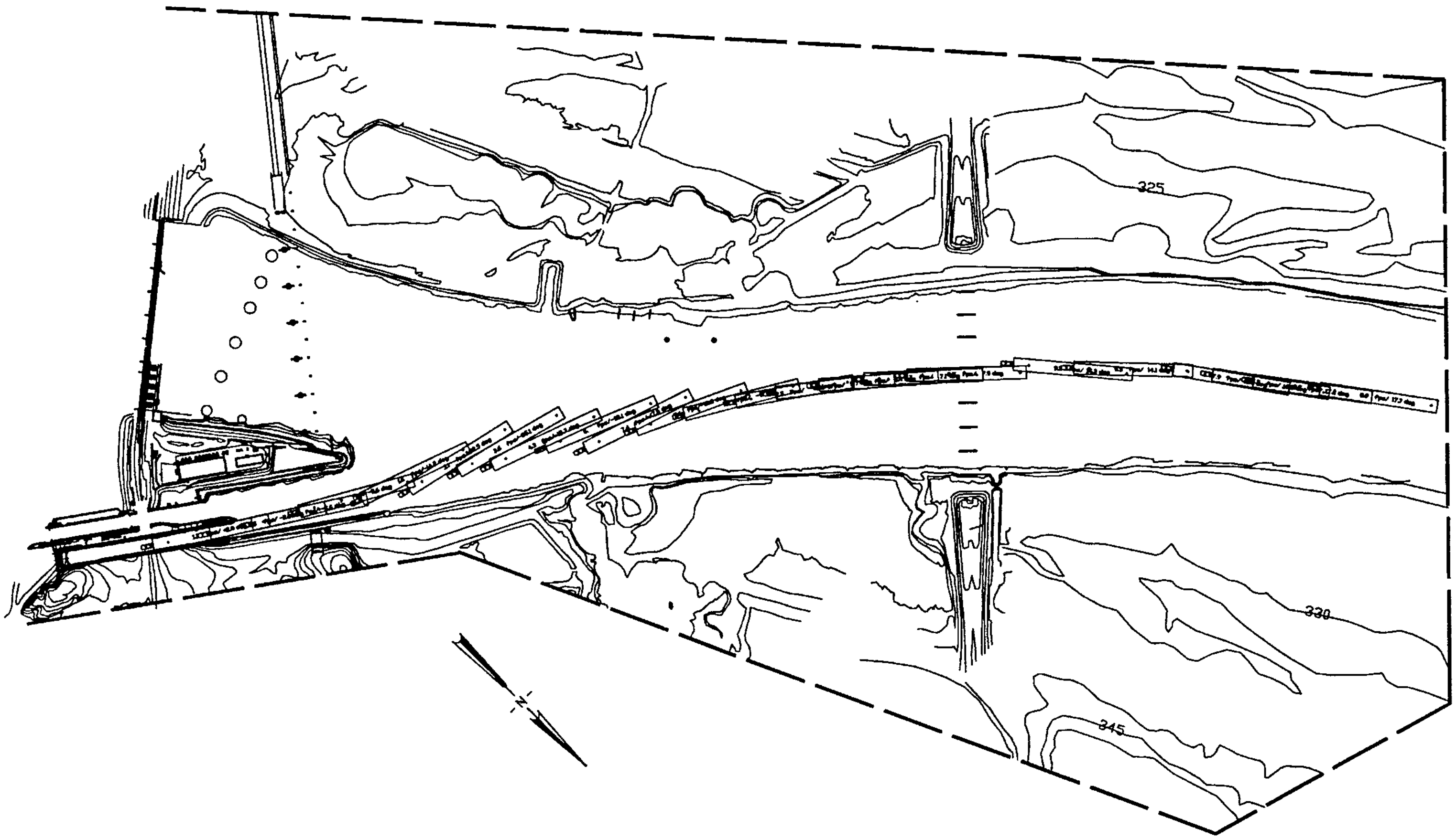
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

TOW TRACKS
PLAN B-1, DOWNBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

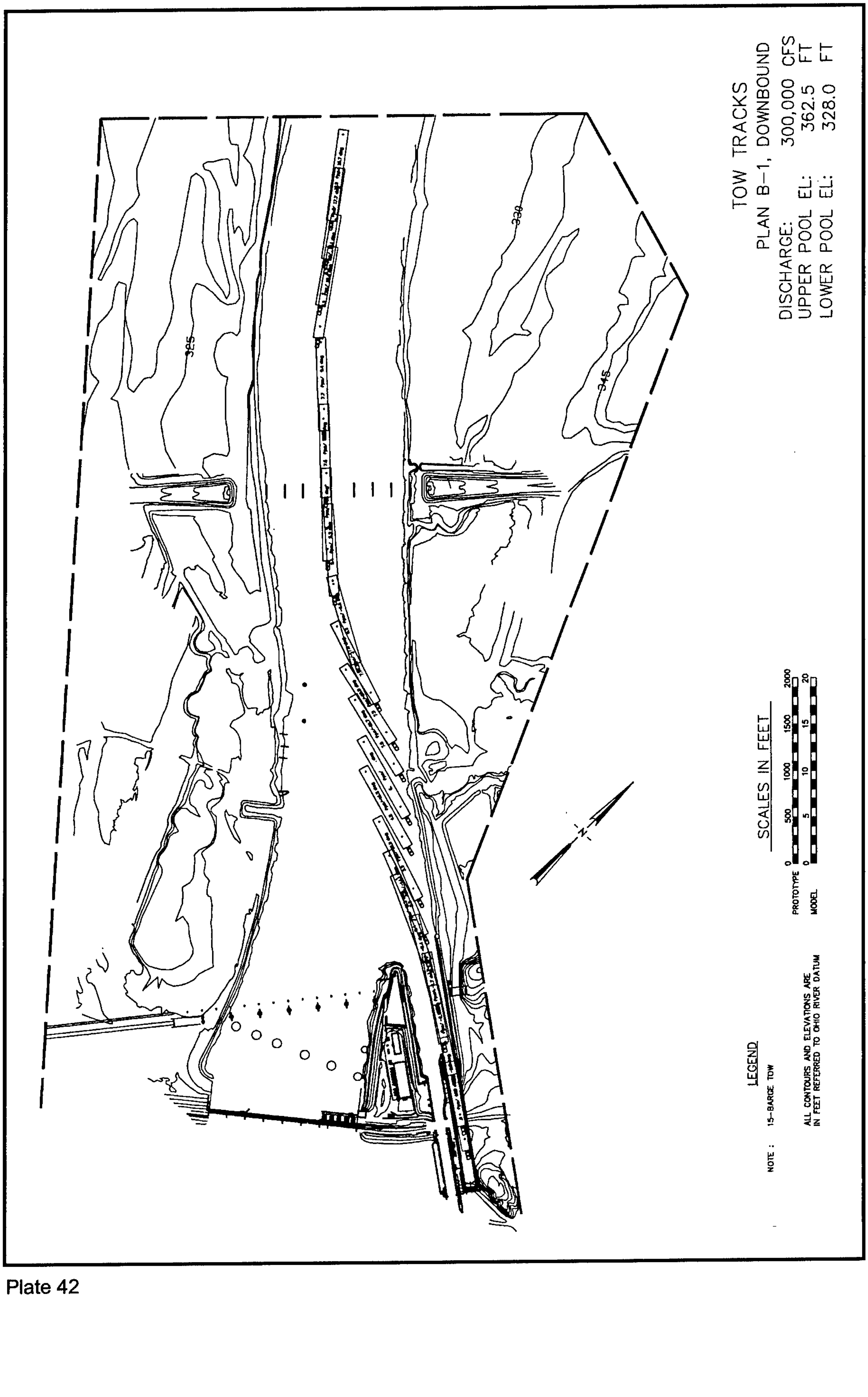
TOW TRACKS

PLAN B–1, DOWNBOUND

DISCHARGE: 100,000 CFS

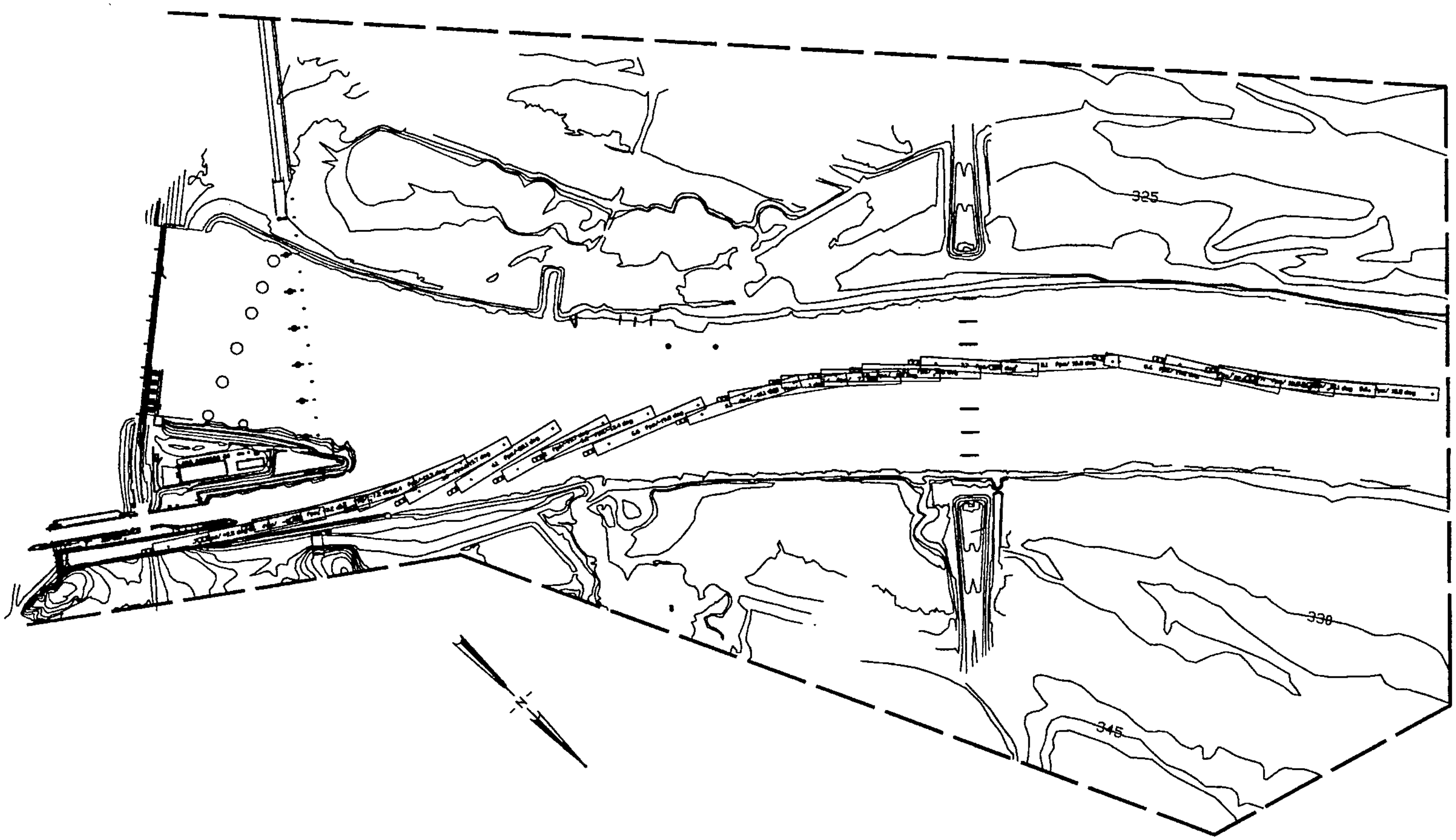
UPPER POOL EL: 358.0 FT

LOWER POOL EL: 306.3 FT



TOW TRACKS
PLAN B-1, DOWNBOUND
DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N

Plate 42



LEGEND

NOTE : 15-BARGE TOW

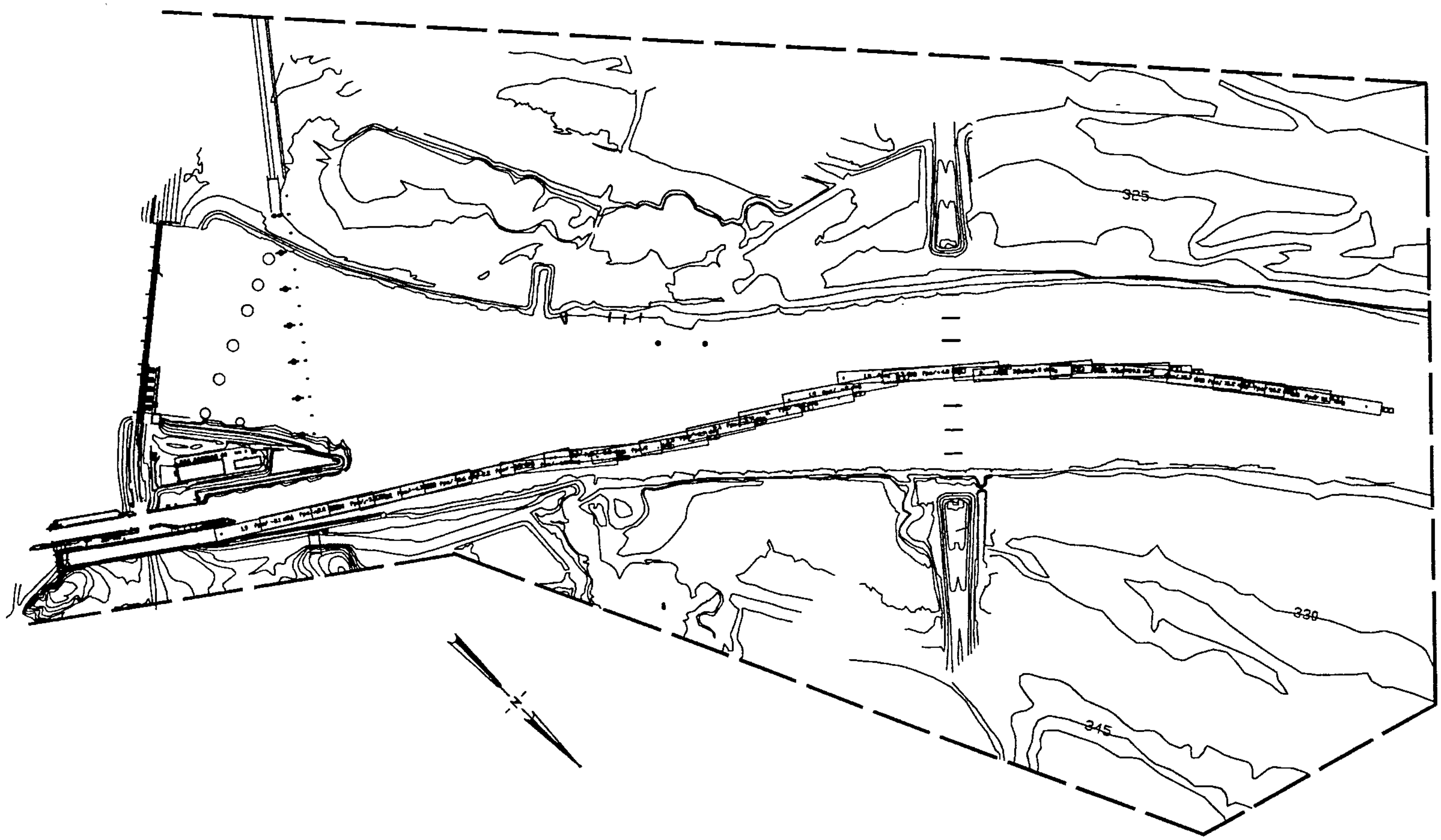
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-1, DOWNBOUND

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

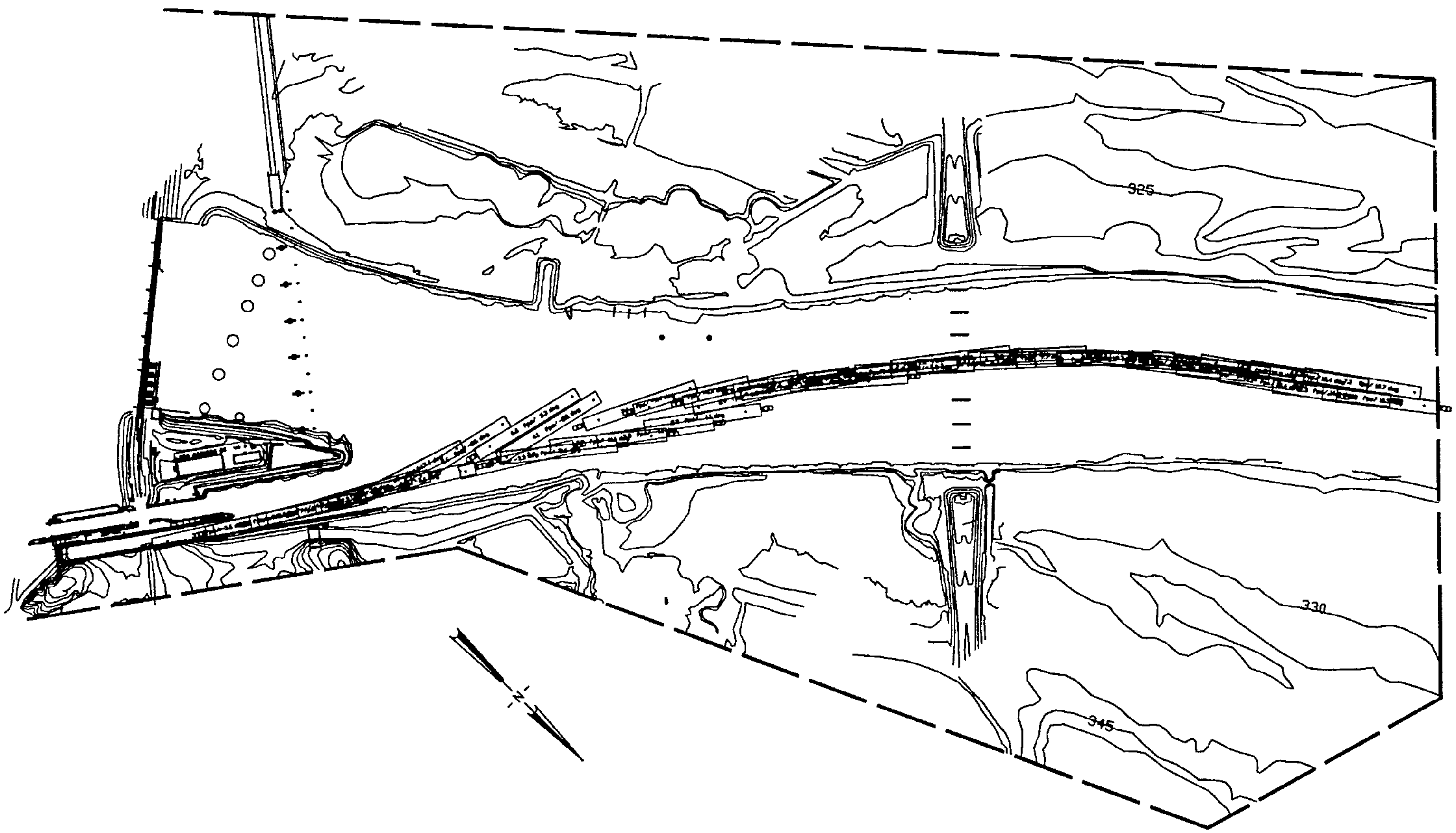
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–1, UPBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

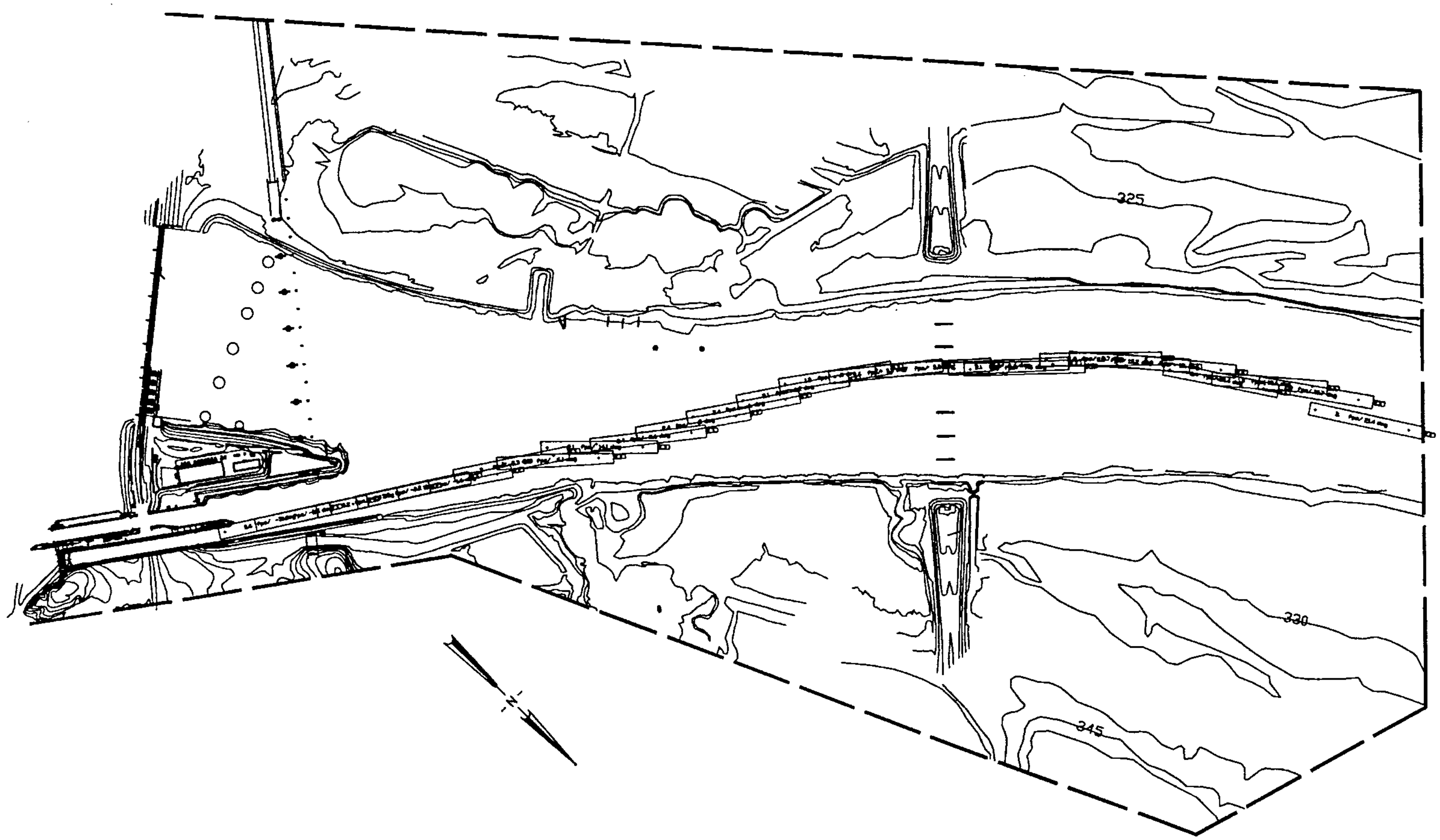
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–1, UPBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

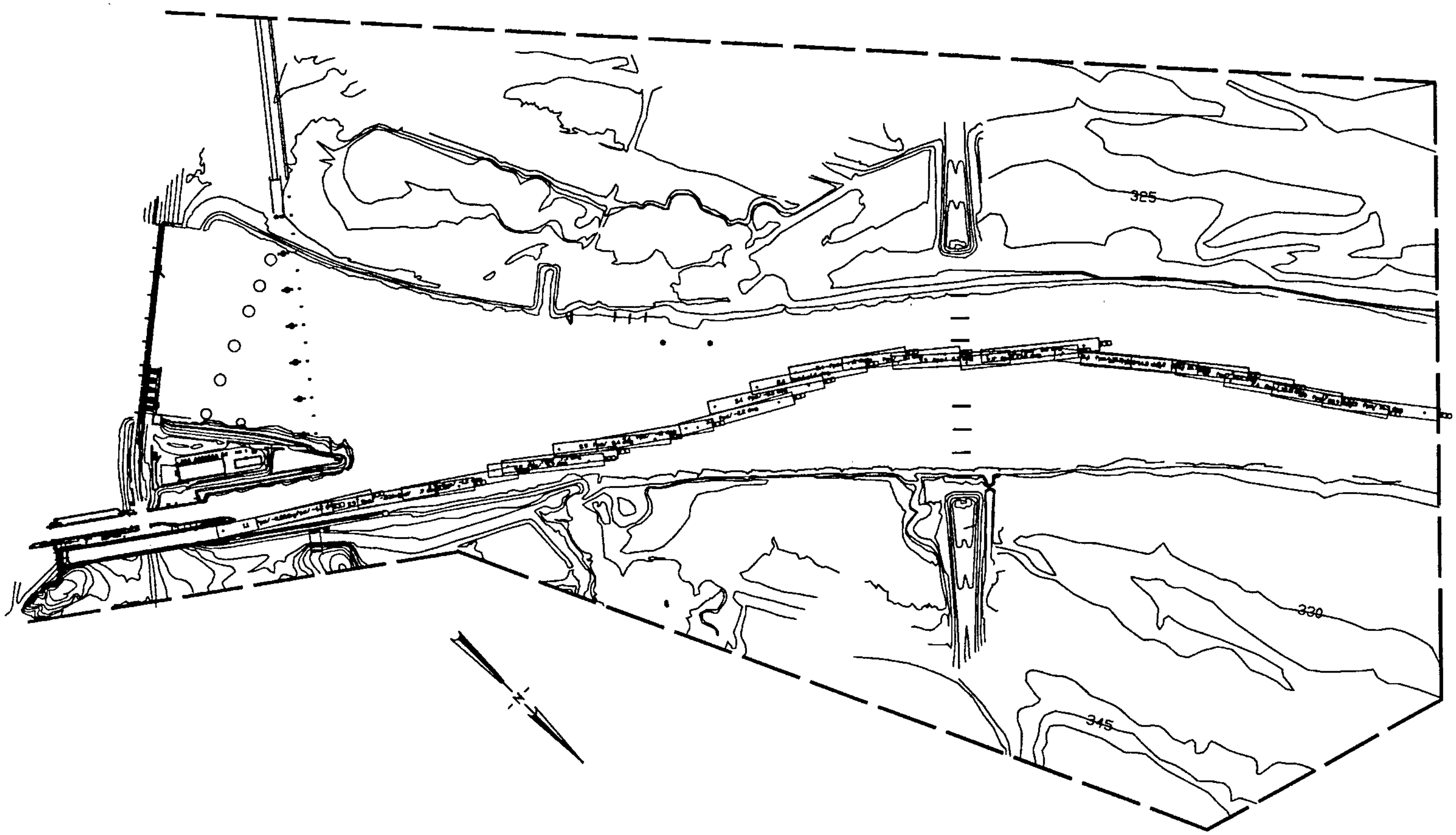
TOW TRACKS

PLAN B–1, UPBOUND

DISCHARGE: 100,000 CFS

UPPER POOL EL: 358.0 FT

LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15–BARGE TOW

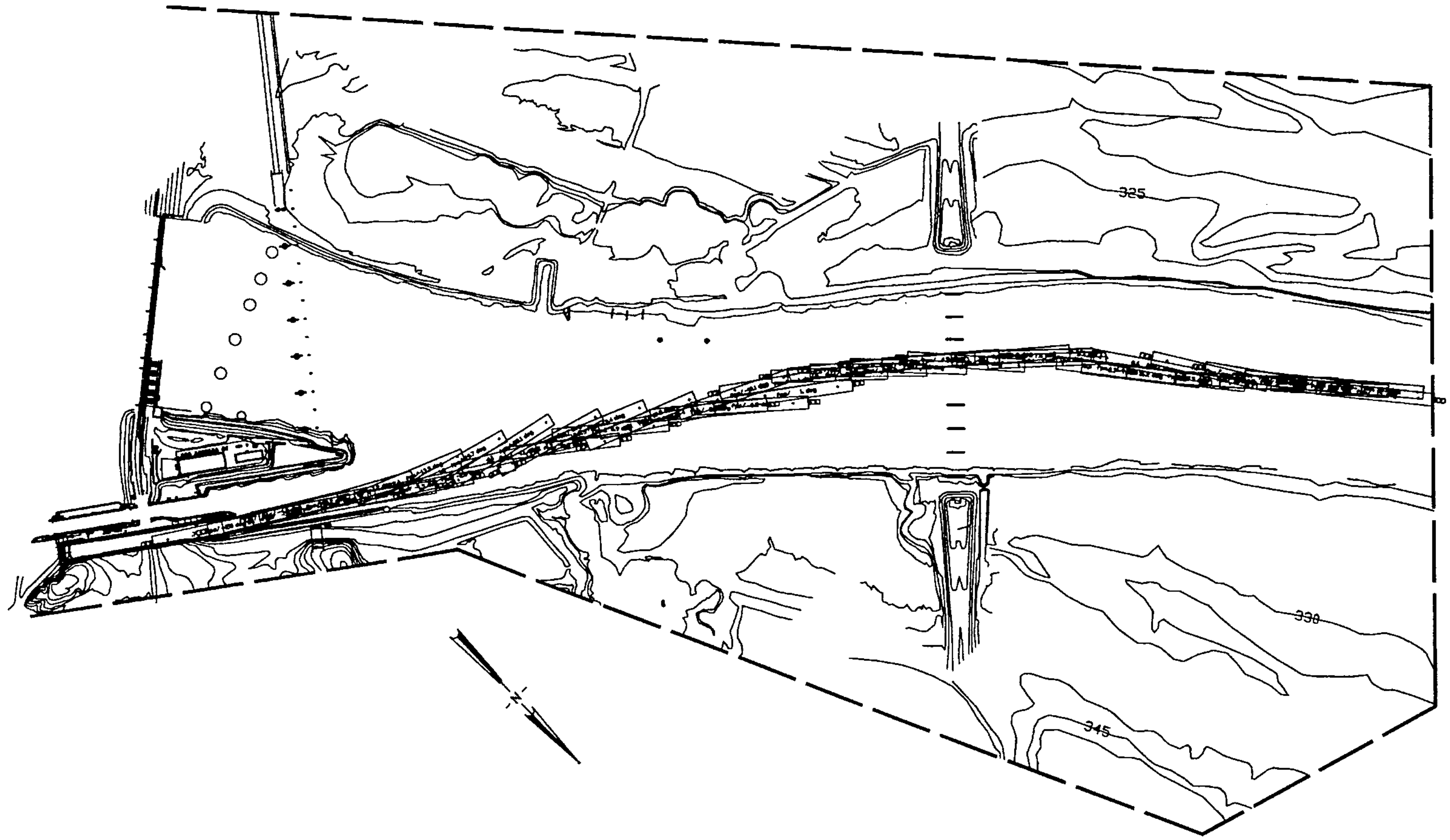
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B–1, UPBOUND

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

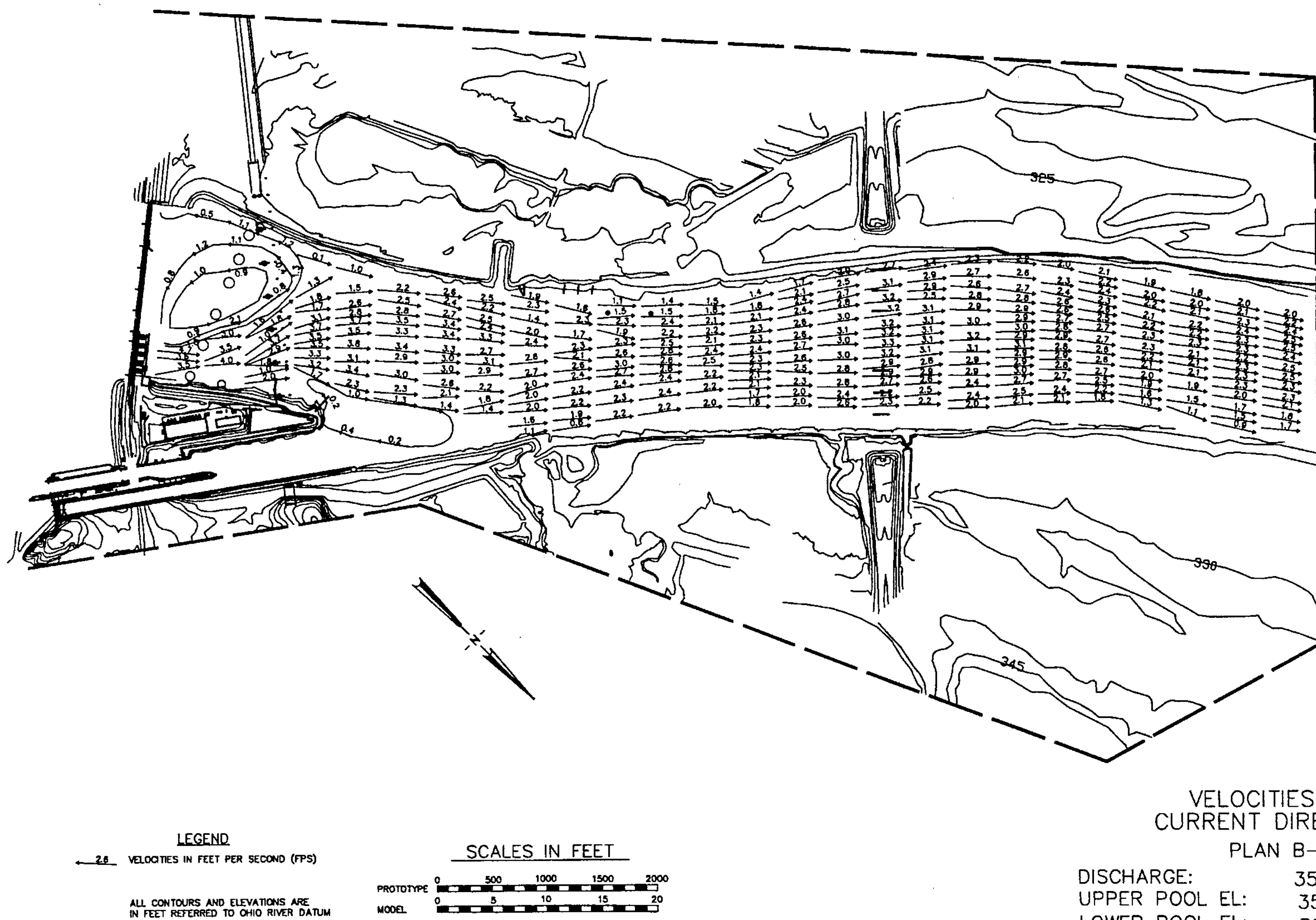
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-1, UPBOUND

DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT

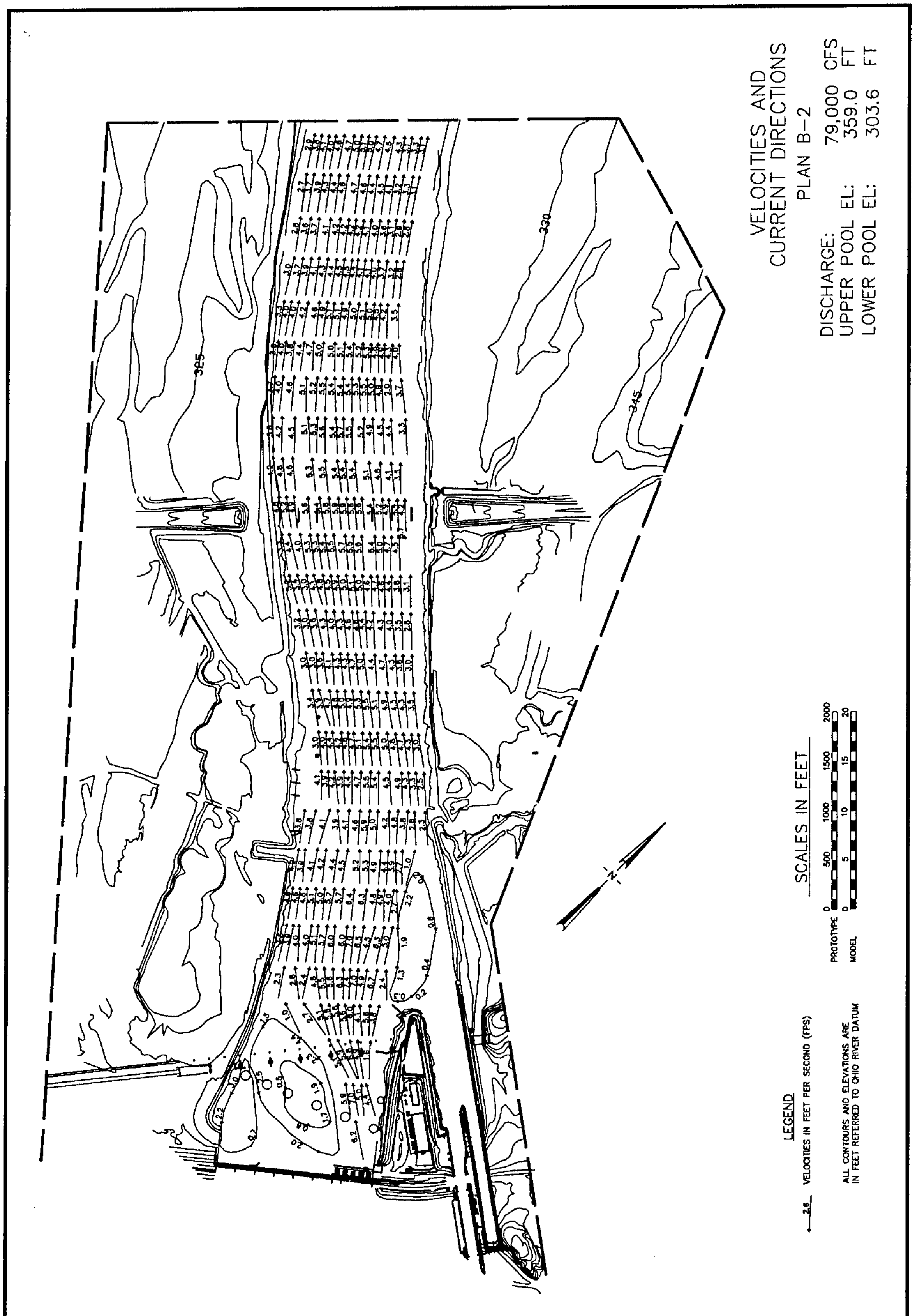
Plate 48



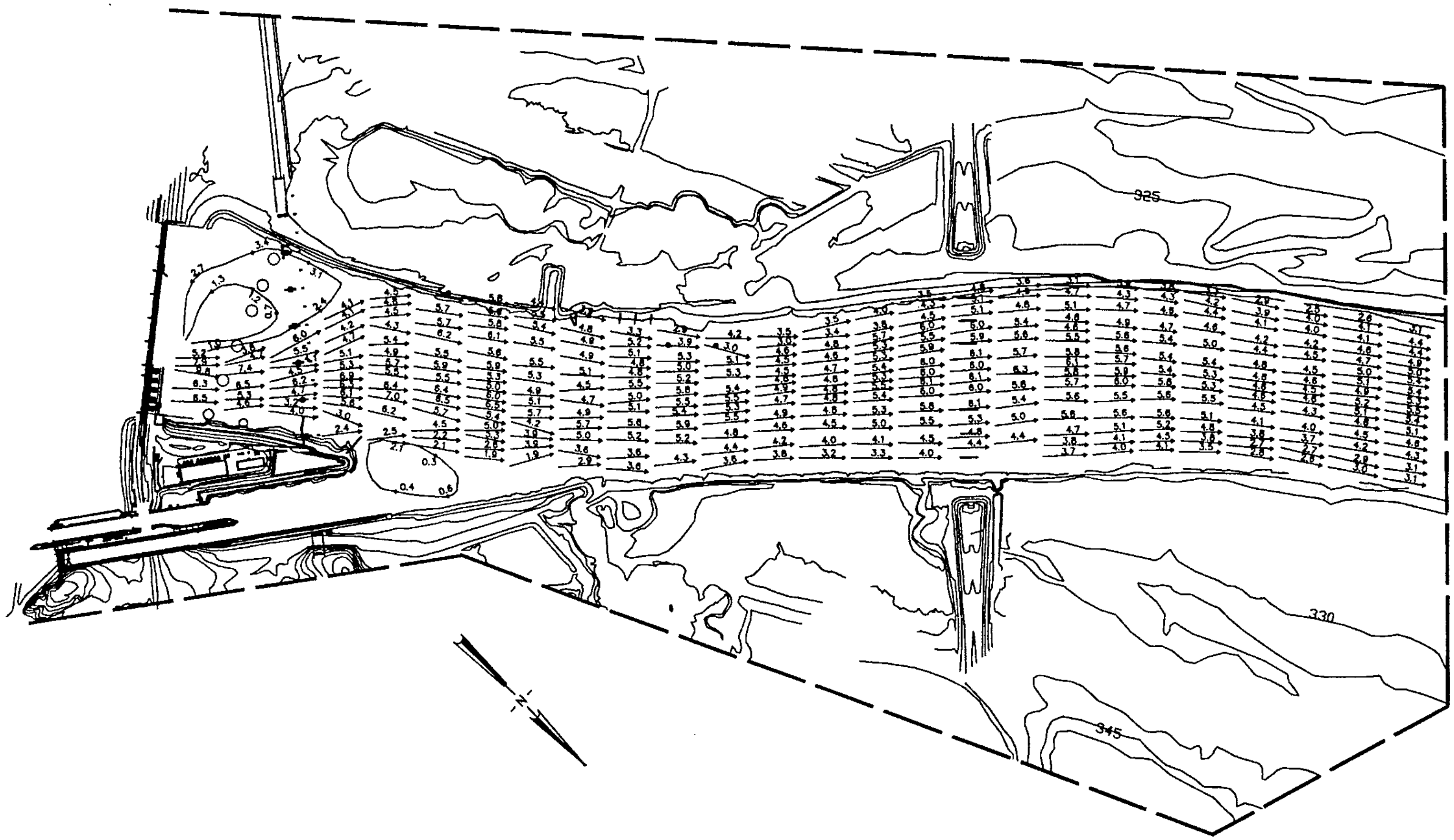
VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT



VELOCITIES AND
CURRENT DIRECTIONS
PLAN B-2
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM



VELOCITIES AND
CURRENT DIRECTIONS

PLAN B–2

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	303.6 FT

LEGEND

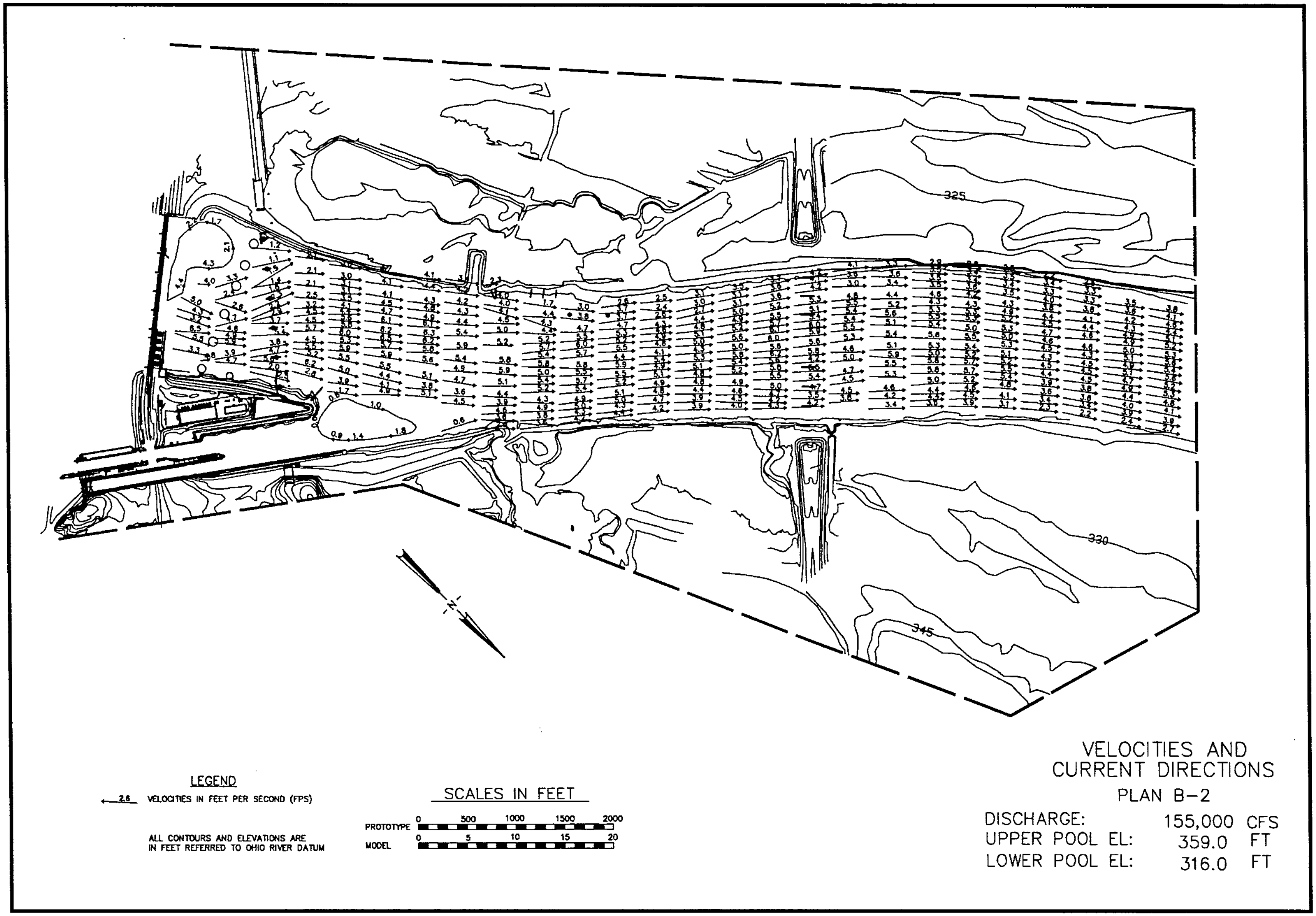
2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

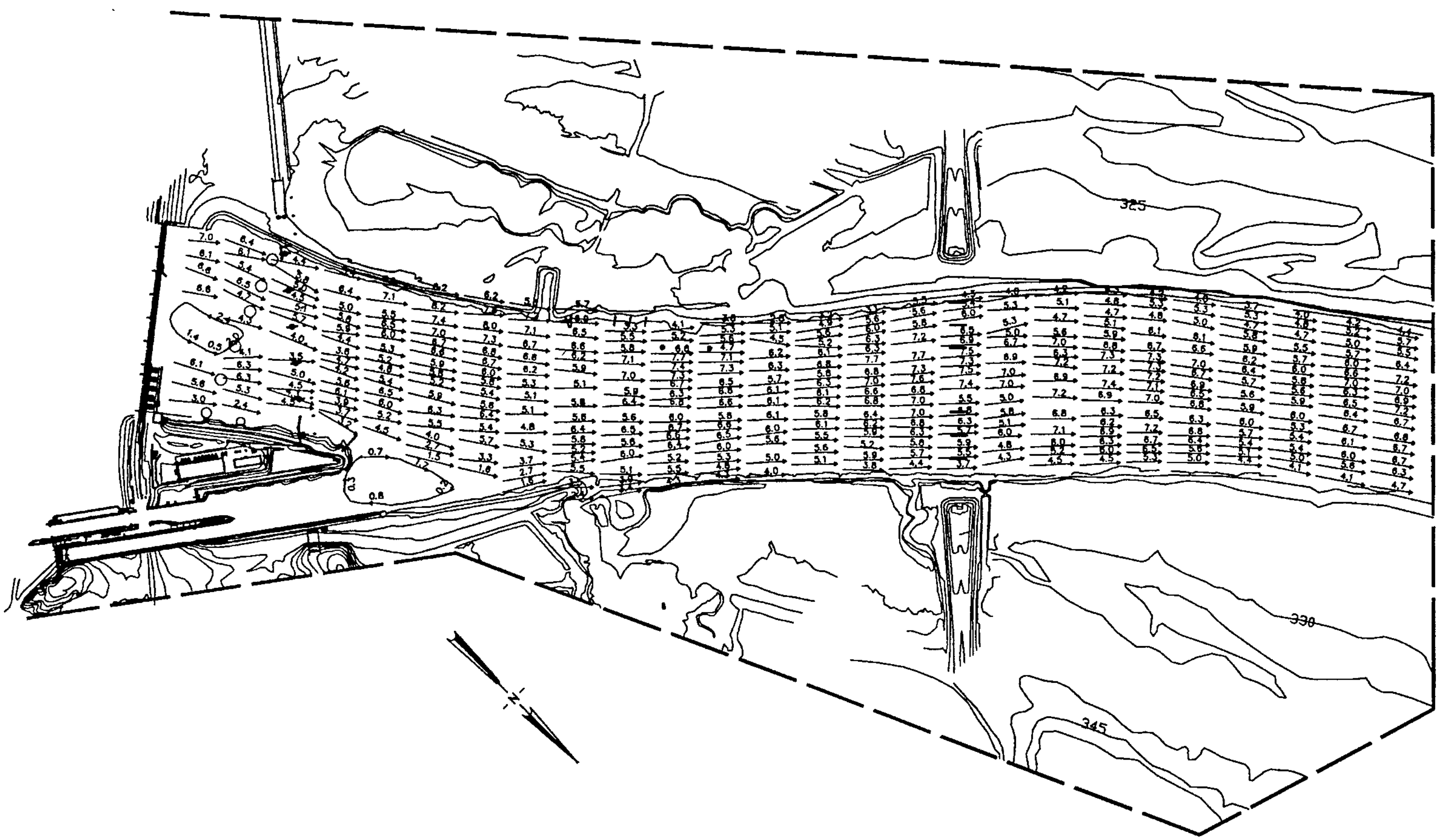
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



325
330
345
LEGEND
2.6 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
VELOCITIES AND CURRENT DIRECTIONS
PLAN B-2
DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

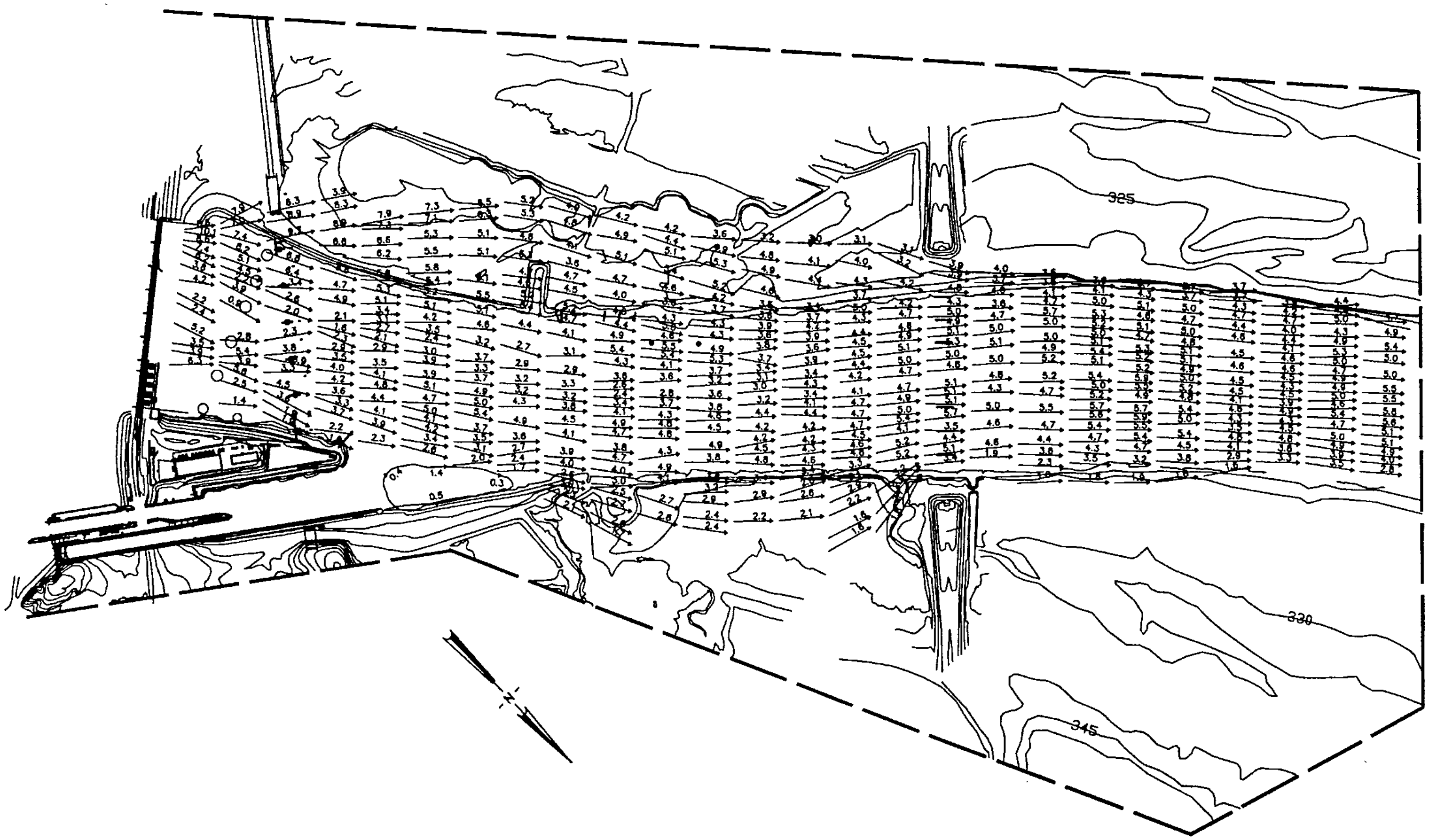
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

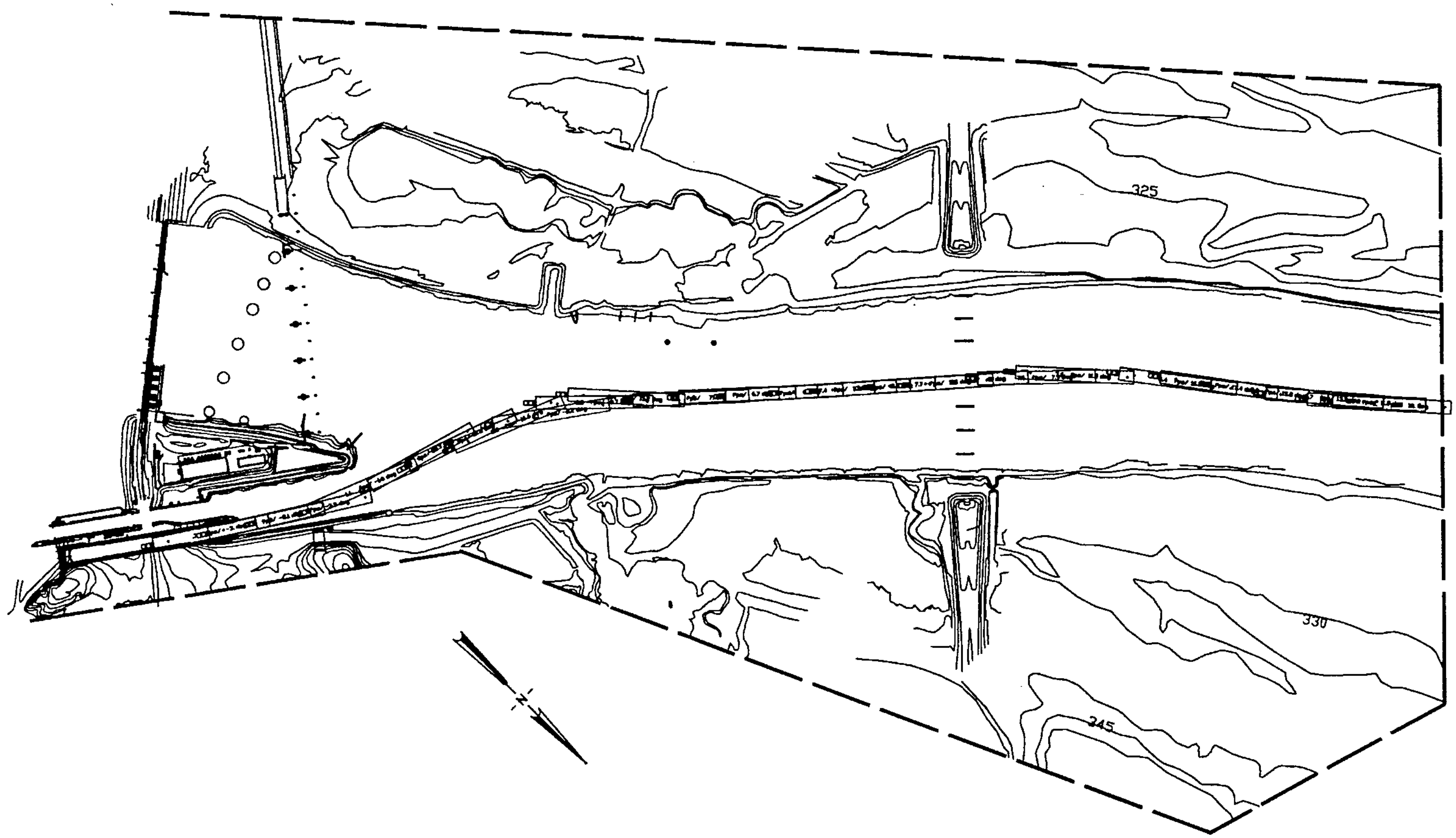
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2

DISCHARGE:	370,000	CFS
UPPER POOL EL:	368.3	FT
LOWER POOL EL:	344.0	FT



TOW TRACKS
PLAN B-2, DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT

LEGEND

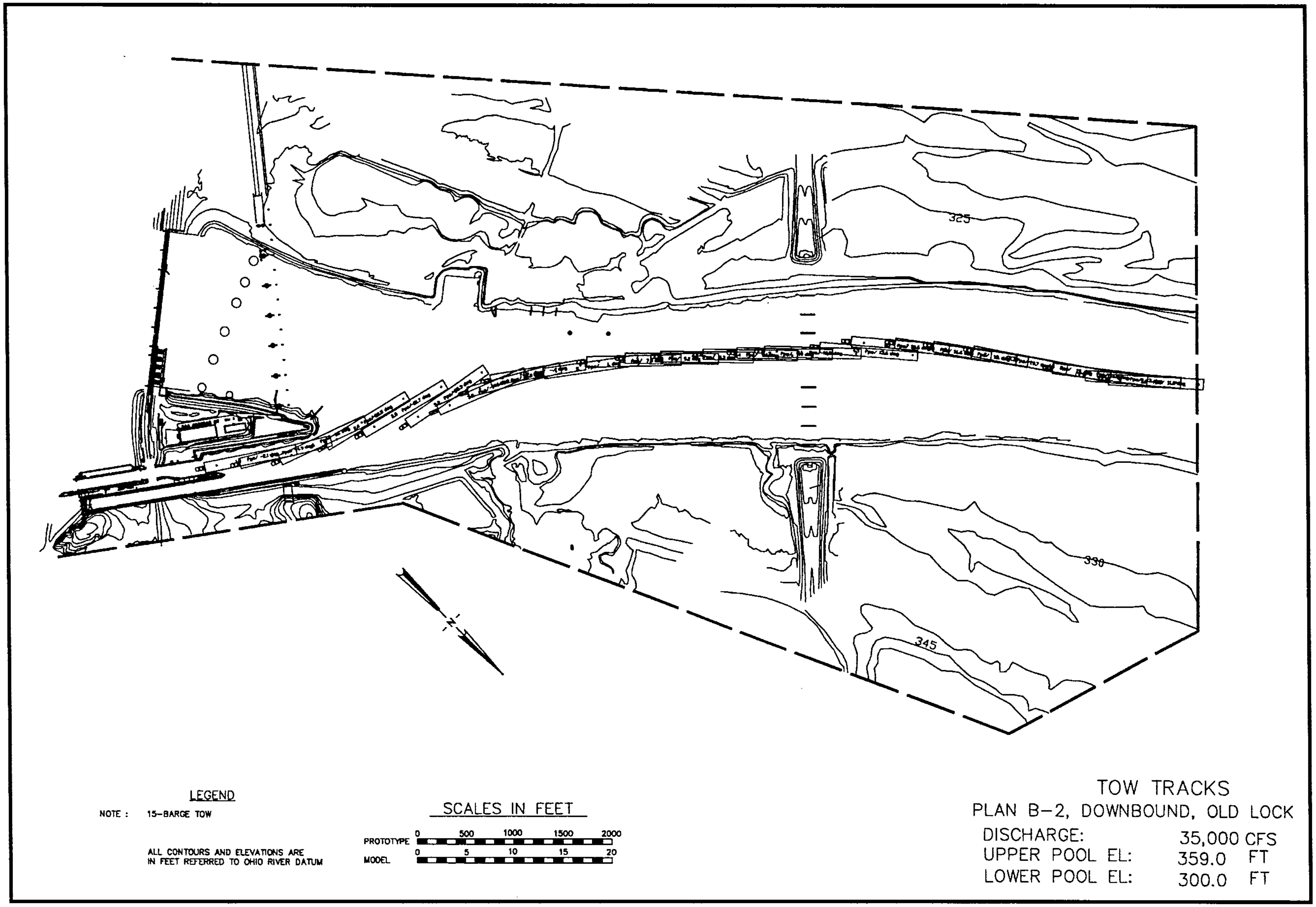
NOTE : 15-BARGE TOW

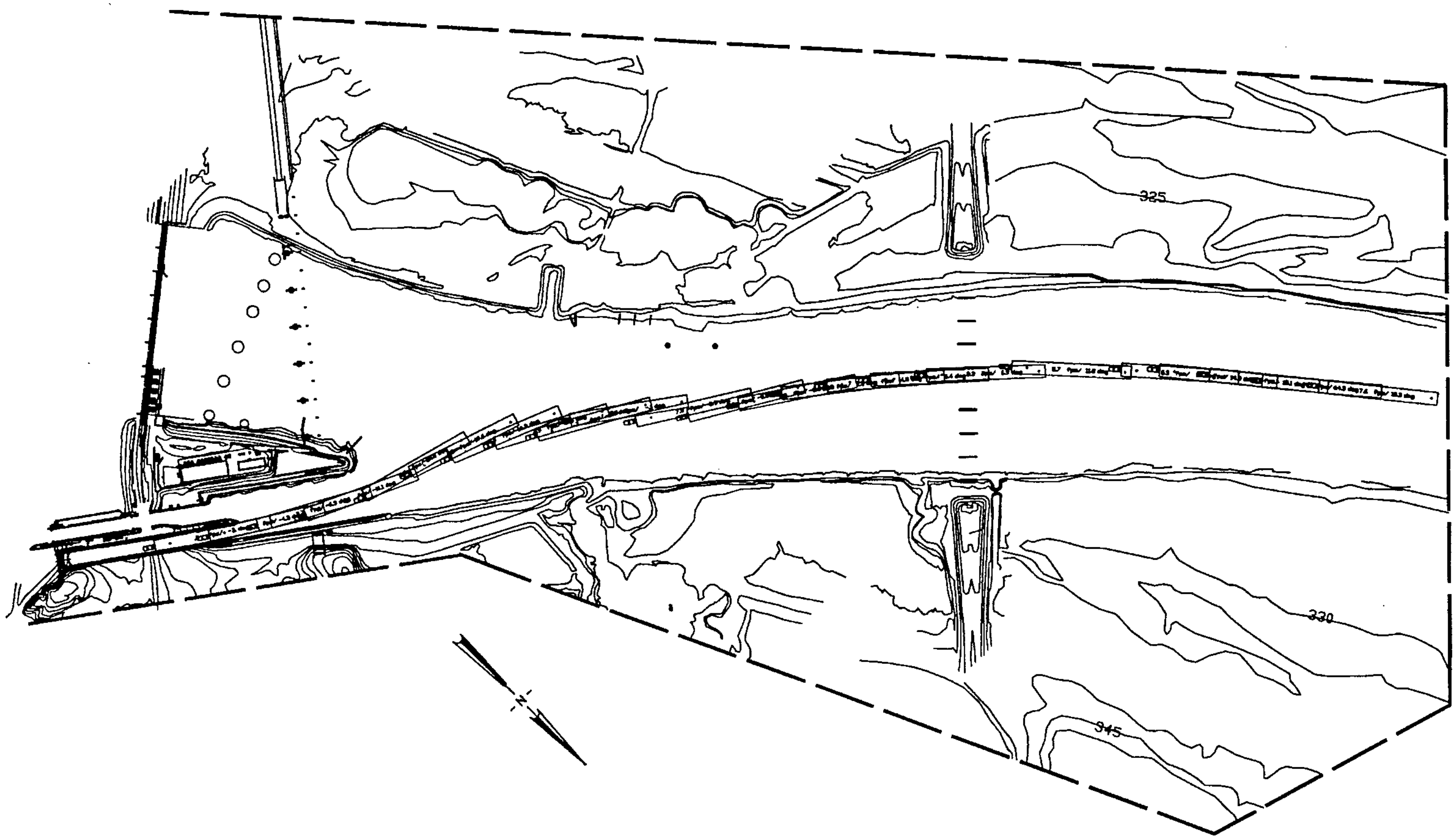
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN B-2, DOWNBOUND, OLD LOCK
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT



LEGEND

NOTE : 15-BARGE TOW

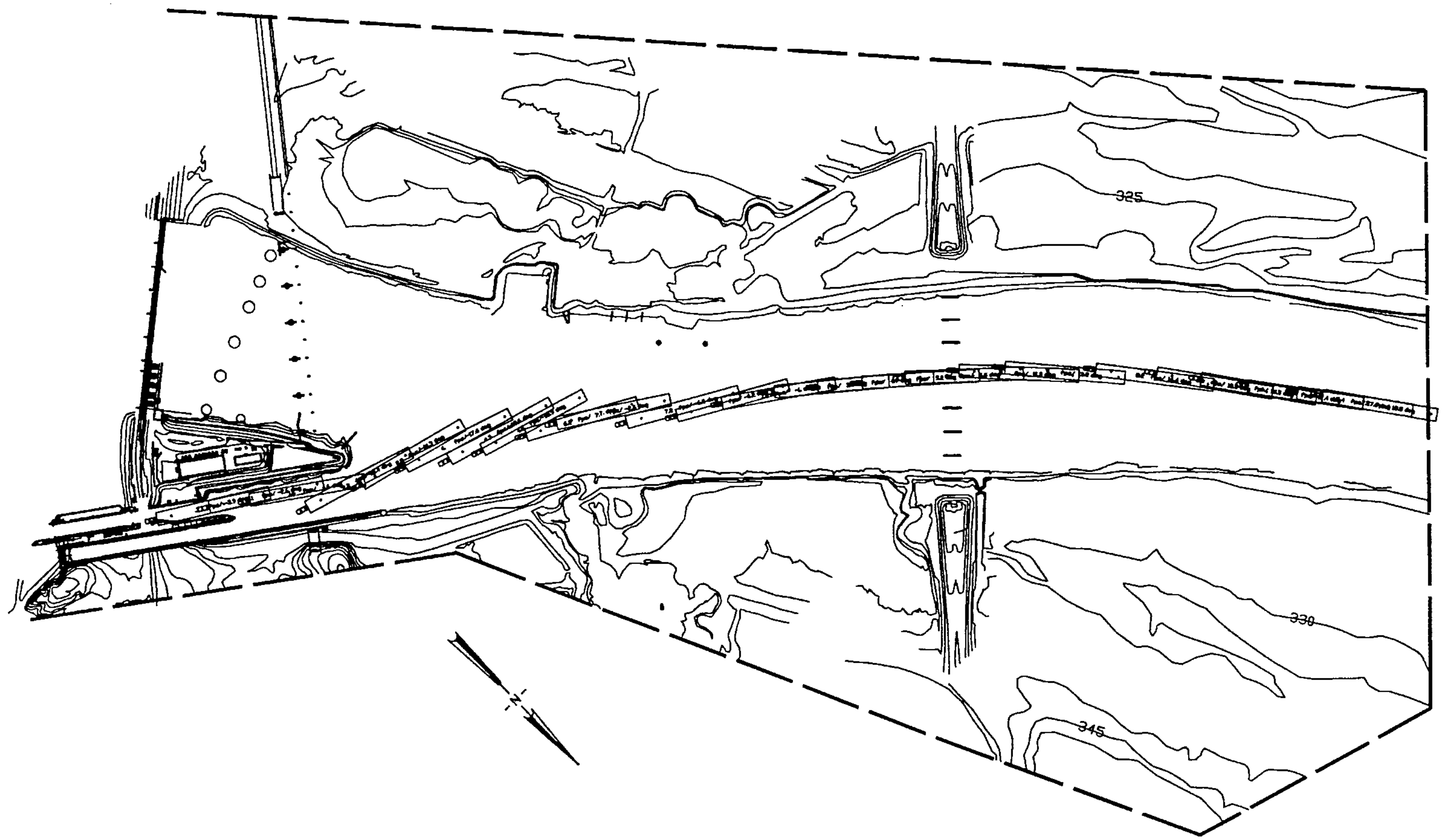
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-2, DOWNBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT

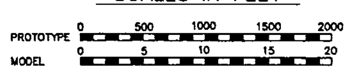


LEGEND

NOTE : 15-BARGE TOW

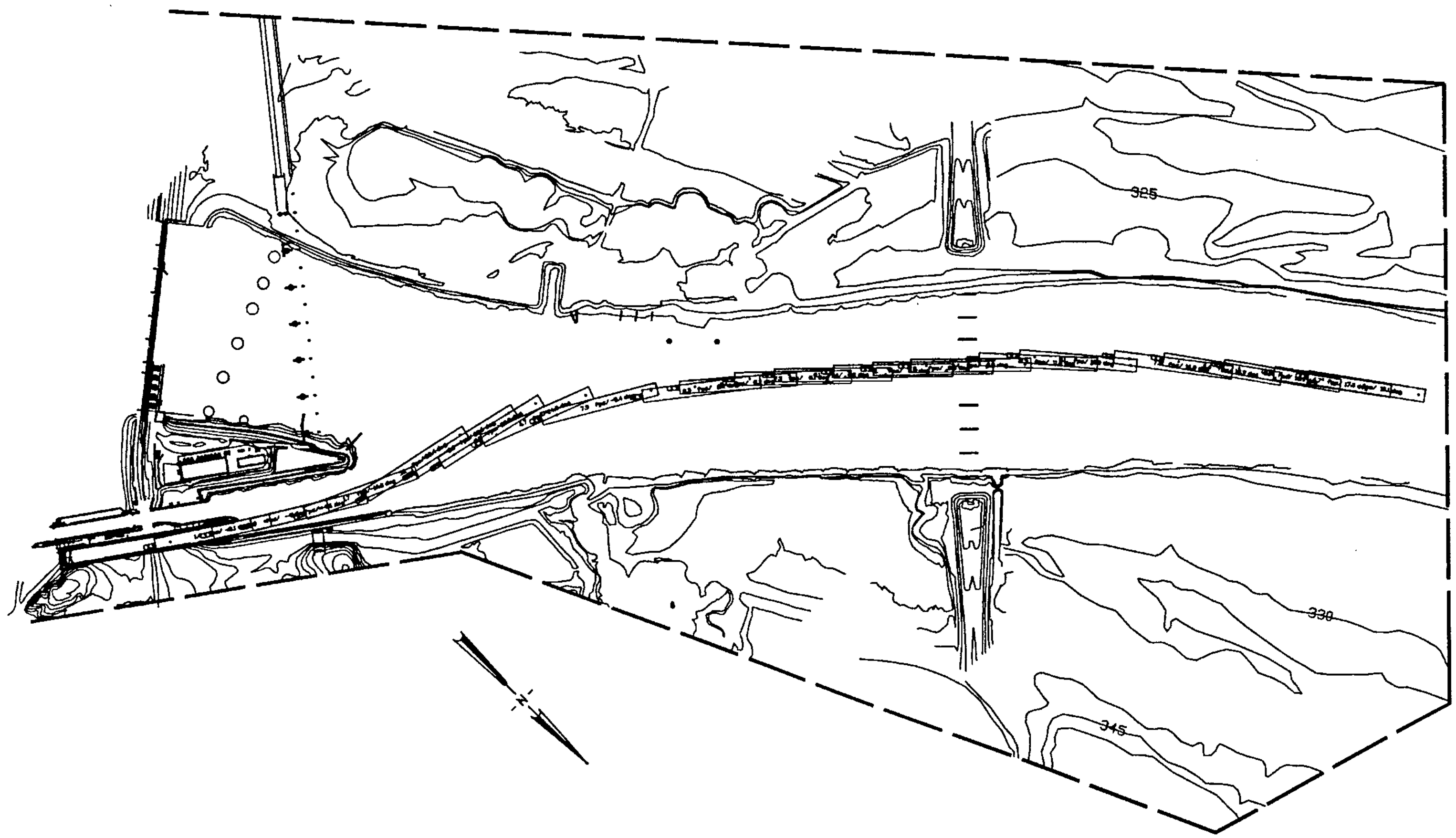
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET



TOW TRACKS
PLAN B-2, DOWNBOUND, OLD LOCK

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

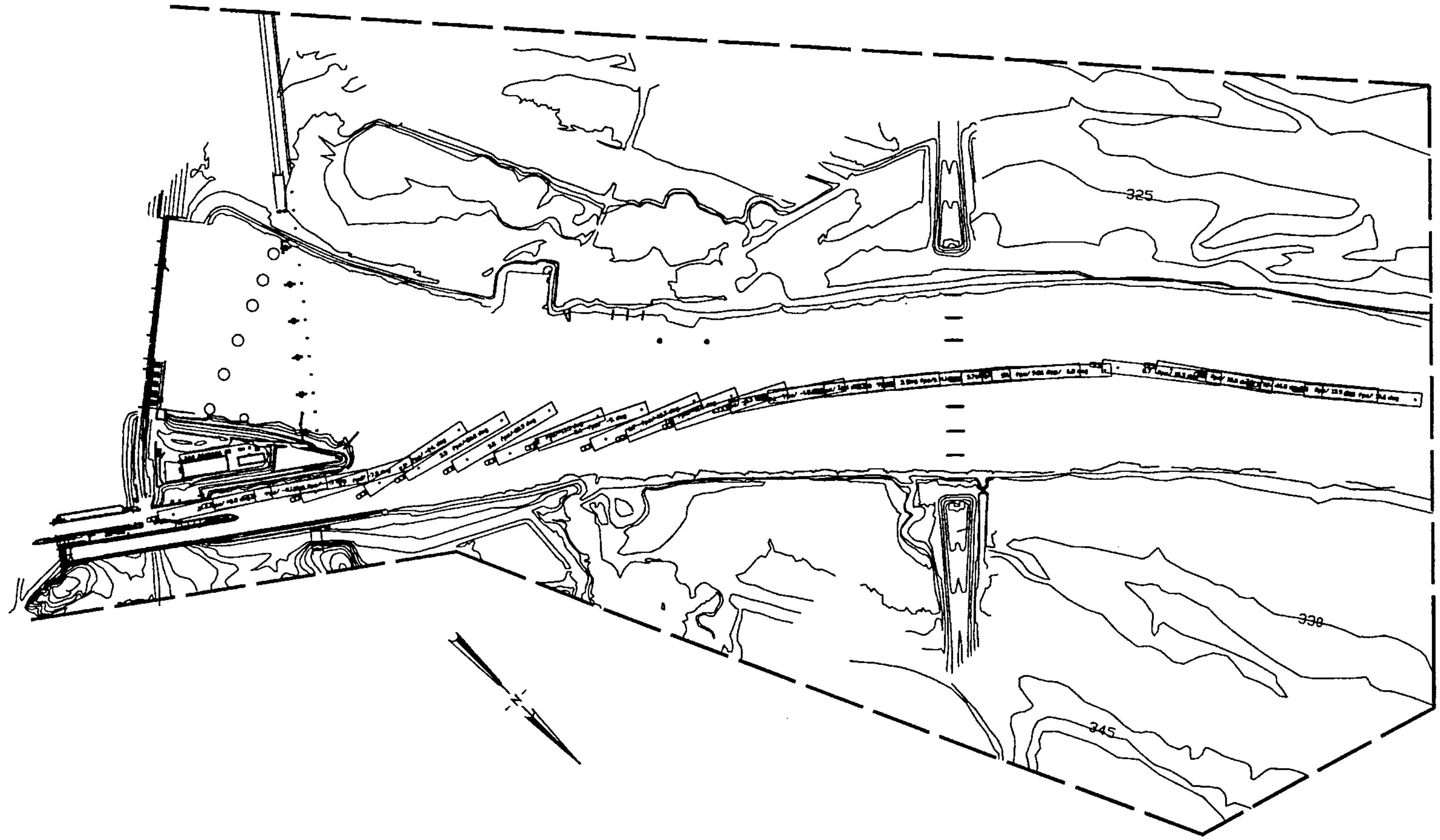
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–2, DOWNBOUND

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	303.6	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

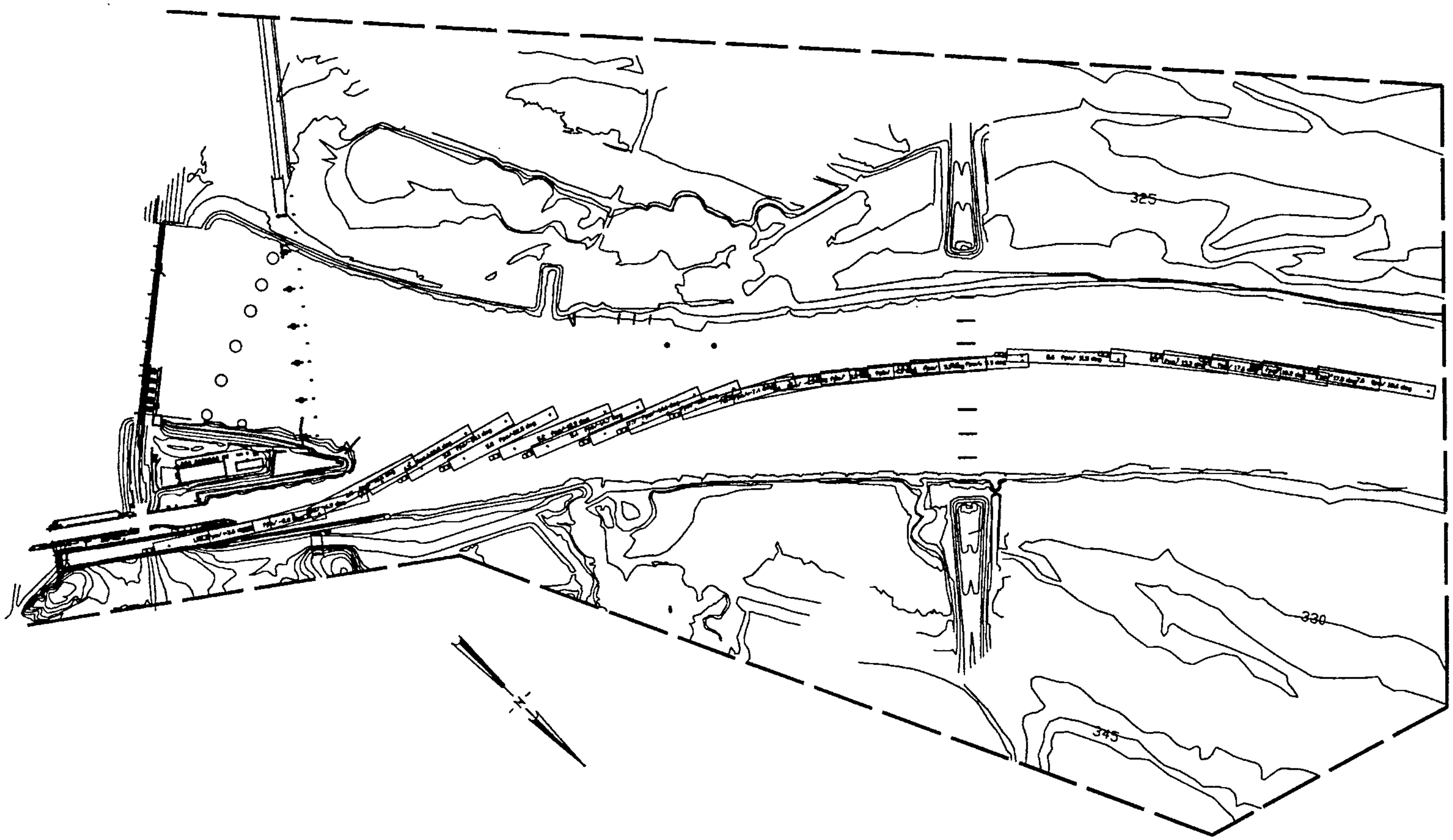
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, DOWNBOUND, OLD LOCK

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



TOW TRACKS
PLAN B–2, DOWNBOUND

DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT

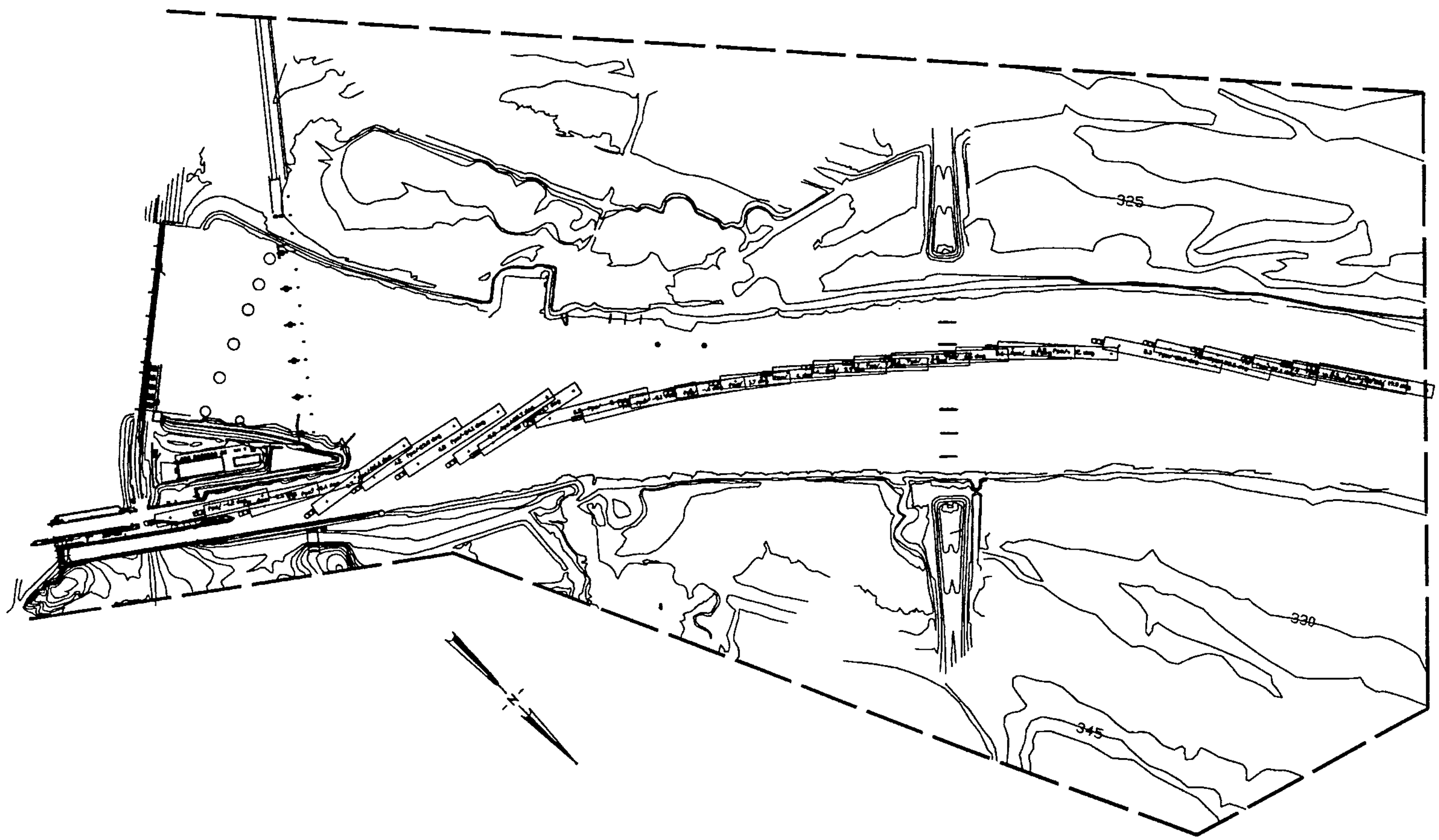
LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20



LEGEND

NOTE : 15-BARGE TOW

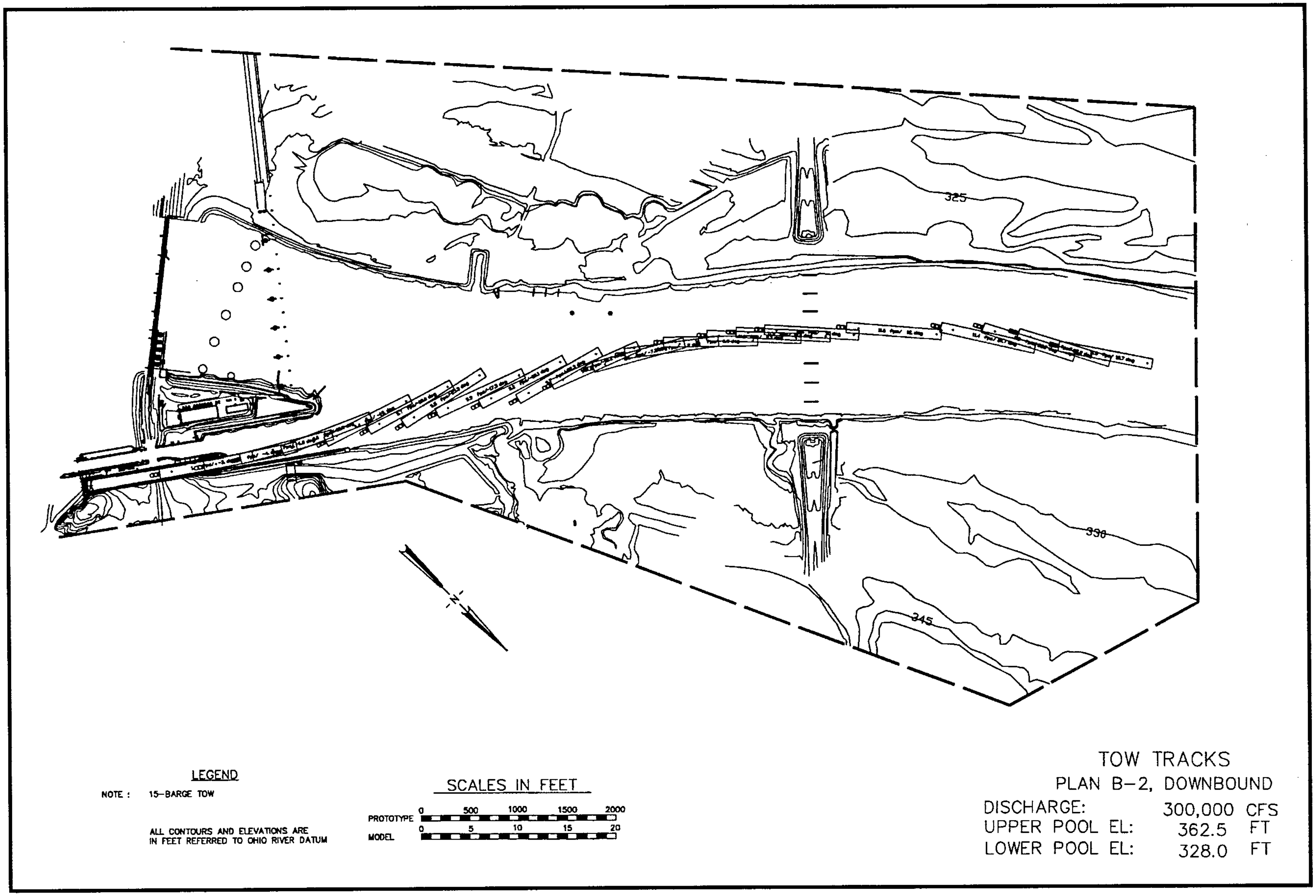
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

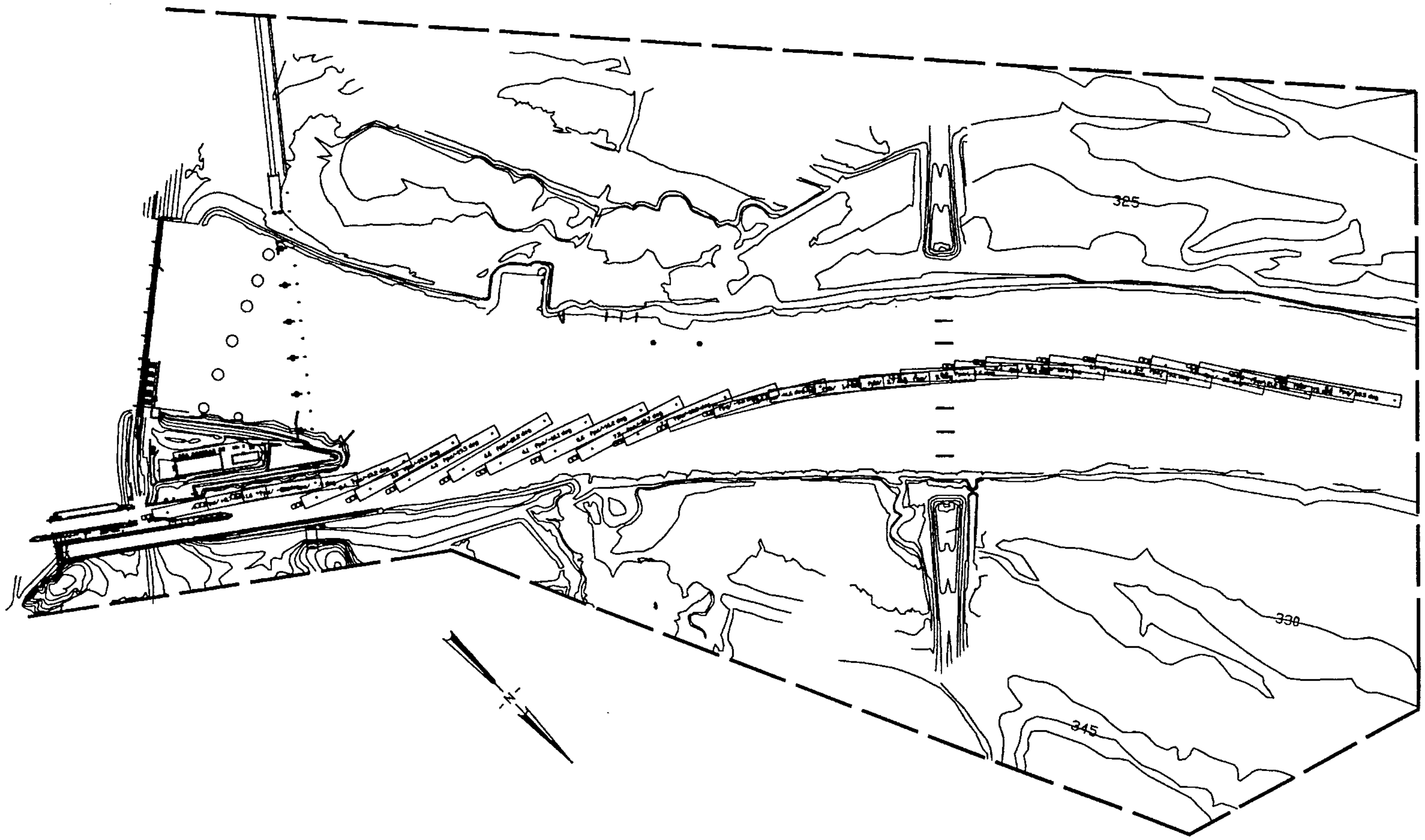
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-2, DOWNBOUND, OLD LOCK

DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN B-2, DOWNBOUND
DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

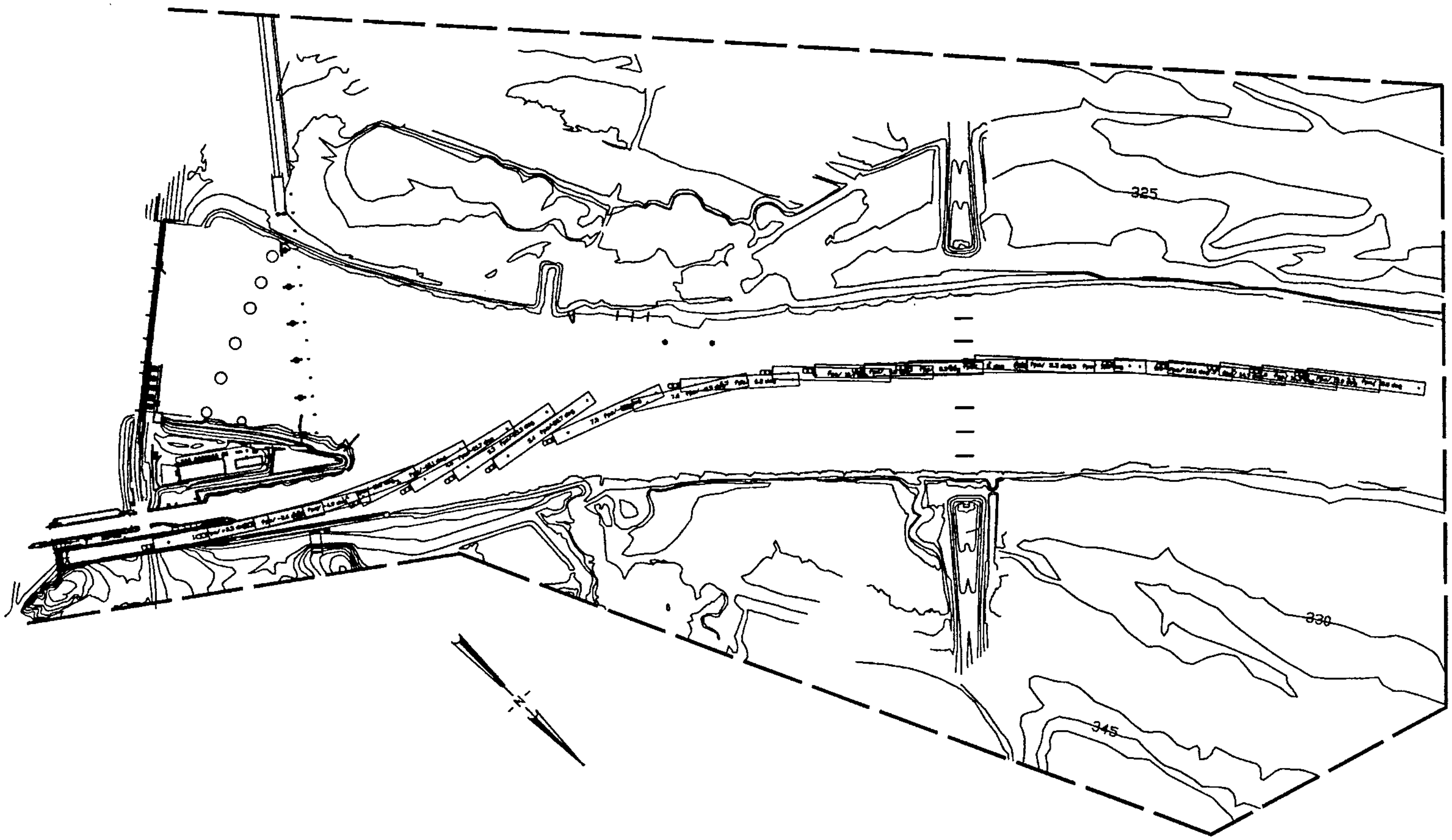
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, DOWNBOUND, OLD LOCK

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



LEGEND

NOTE : 15-BARGE TOW

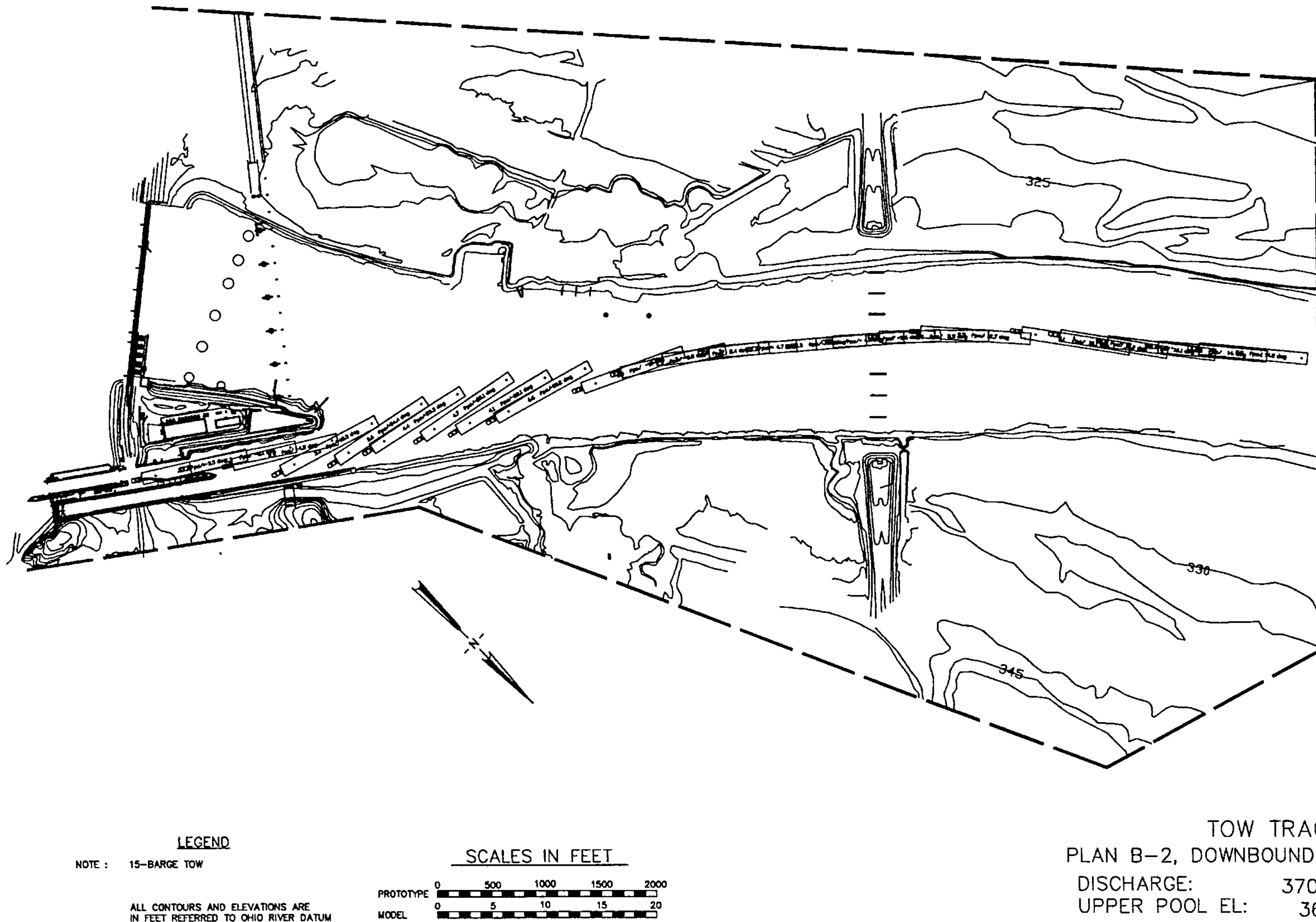
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

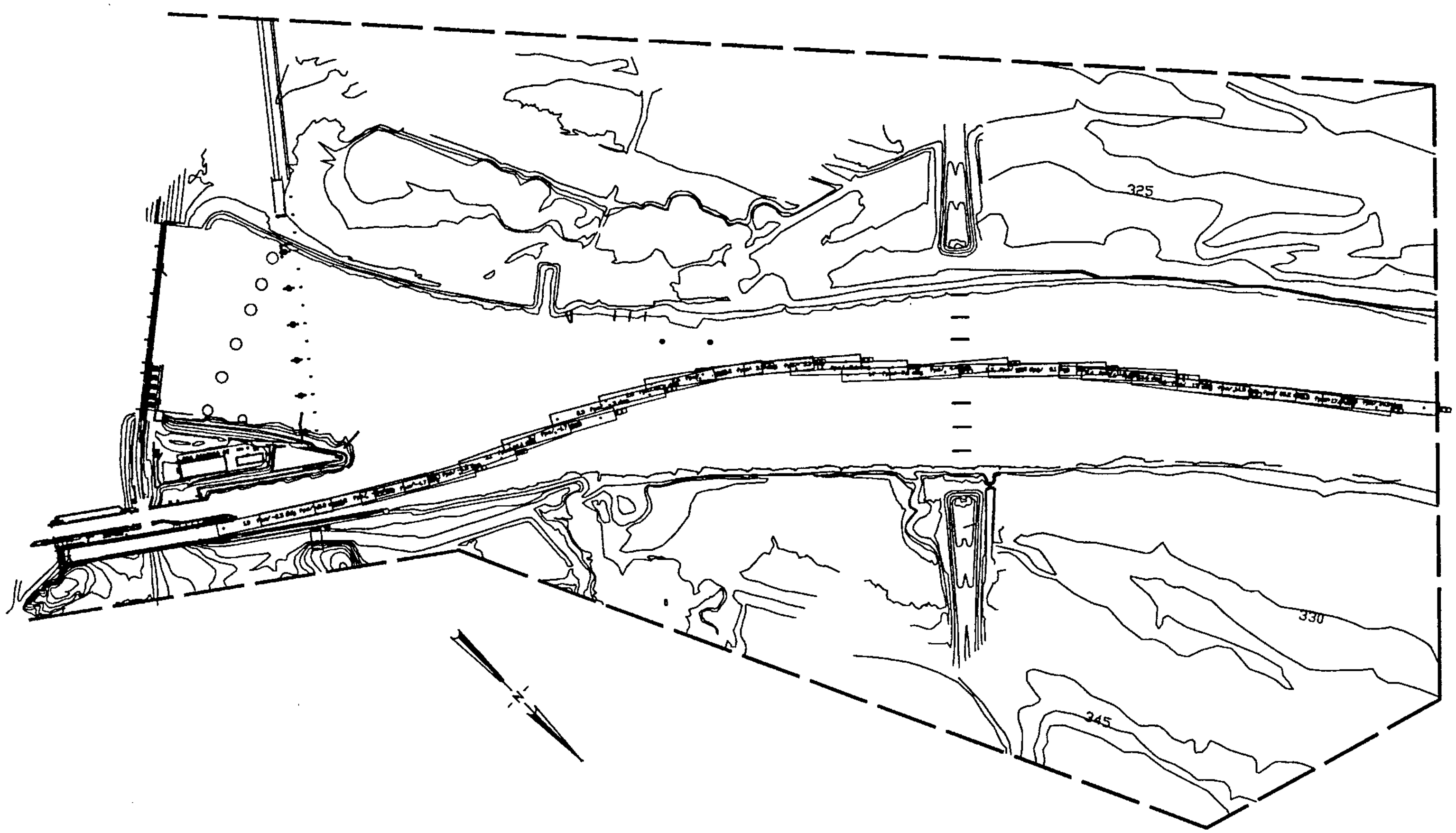
TOW TRACKS
PLAN B-2, DOWNBOUND

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT



TOW TRACKS
PLAN B-2, DOWNBOUND, OLD LOCK

DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT



LEGEND

NOTE : 15-BARGE TOW

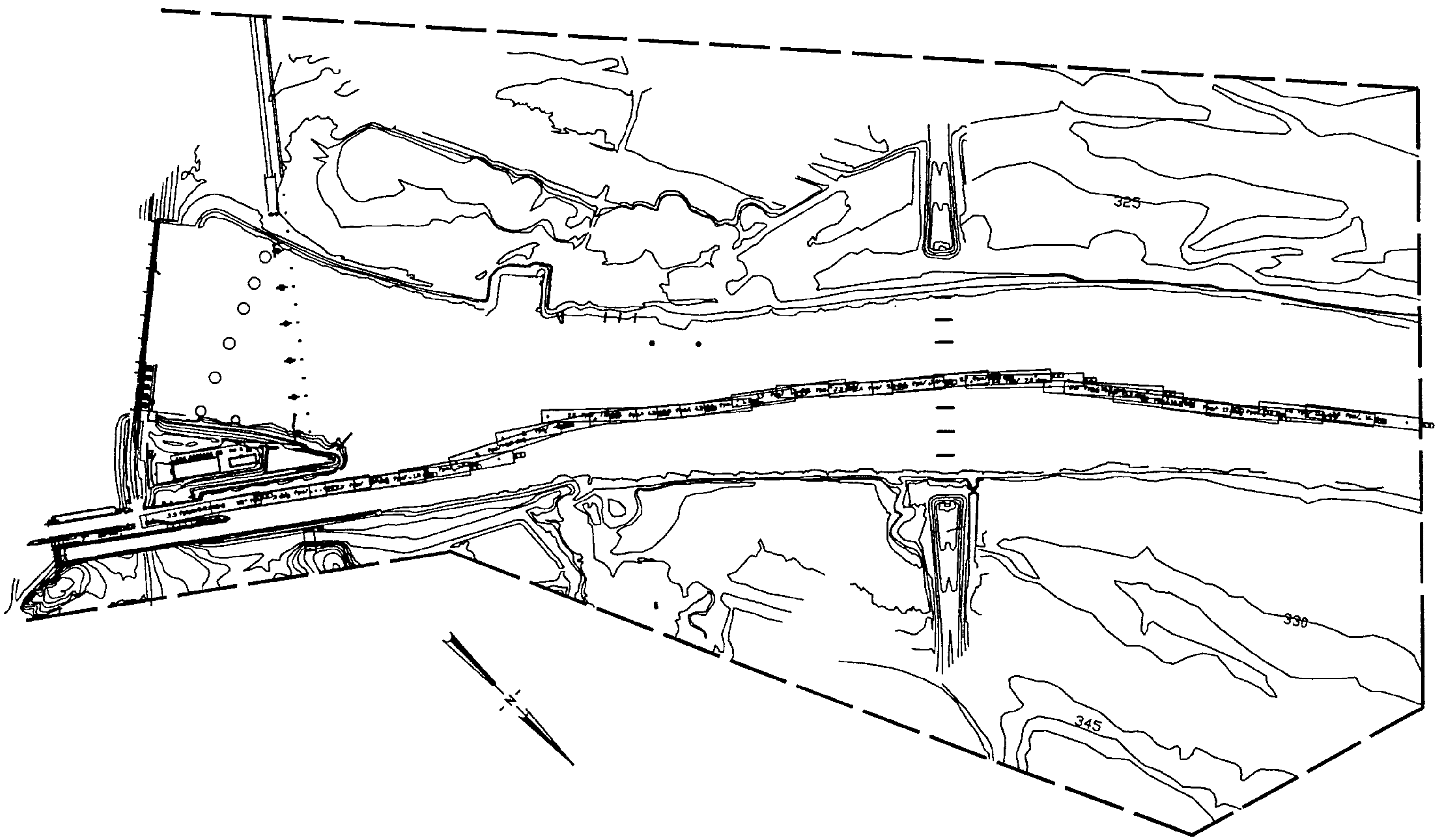
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

TOW TRACKS
PLAN B-2, UPBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

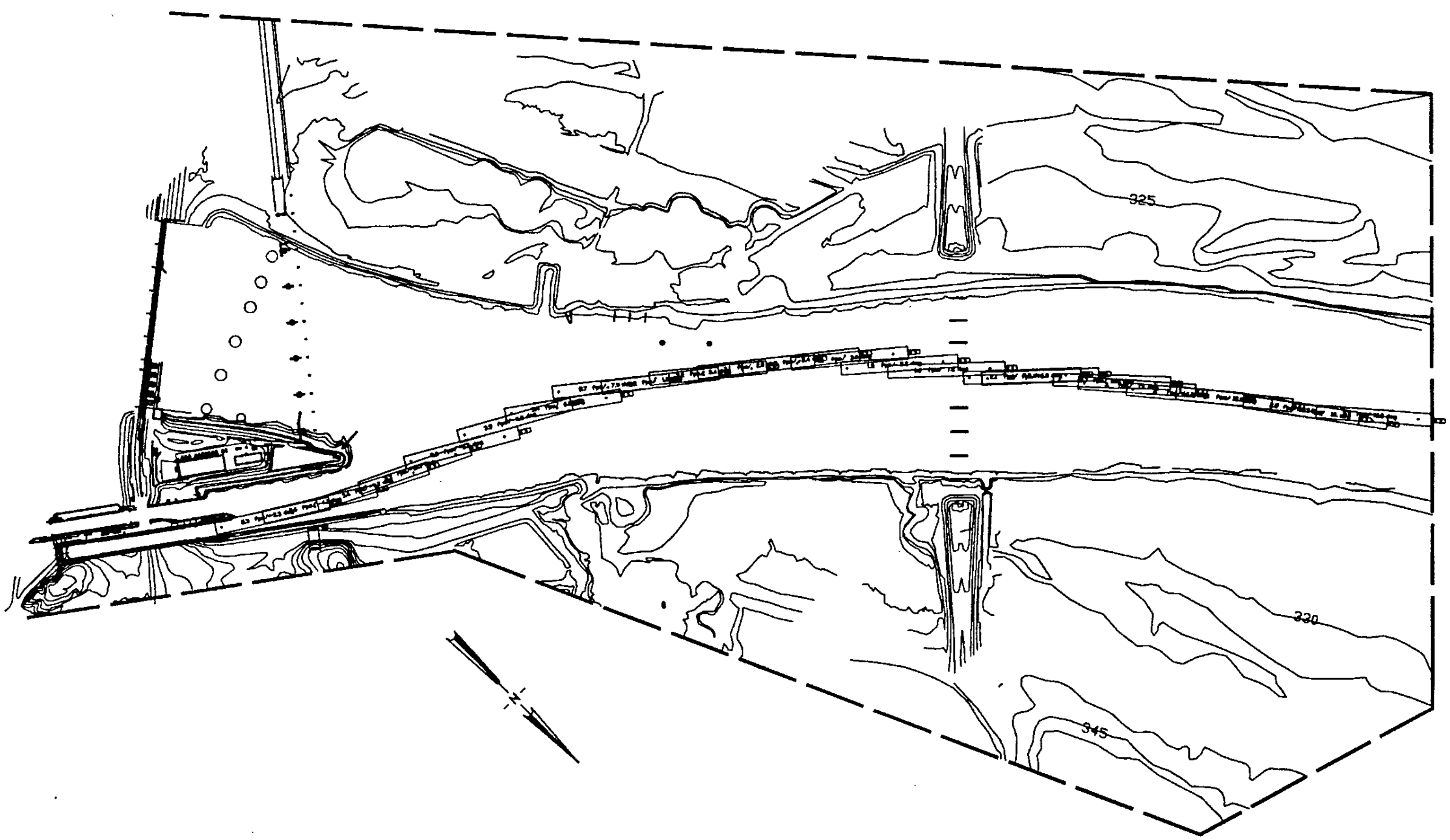
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, UPBOUND, OLD LOCK

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15-BARGE TOW

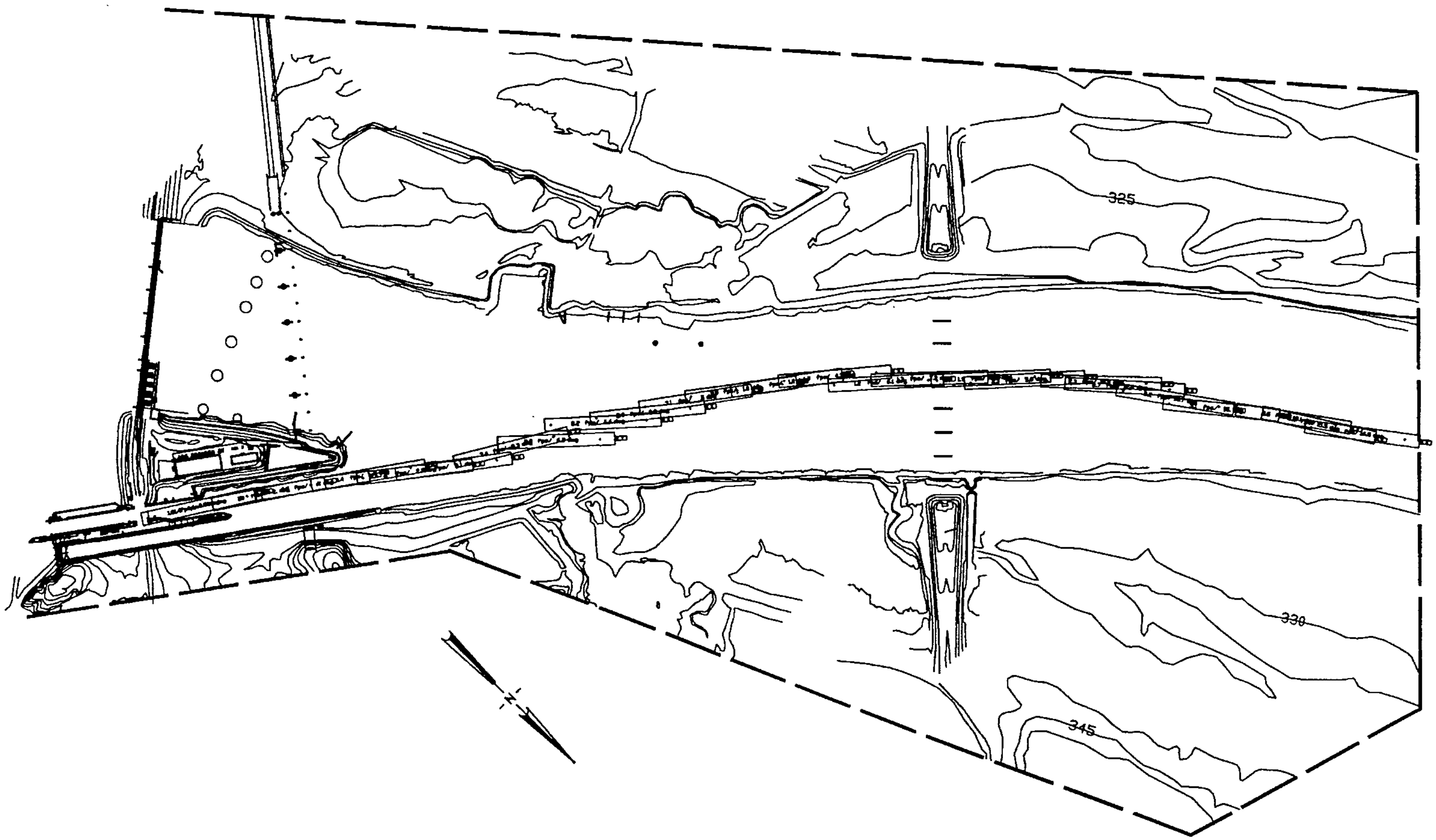
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0 500 1000 1500 2000
MODEL	0 5 10 15 20

TOW TRACKS
PLAN B-2, UPBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

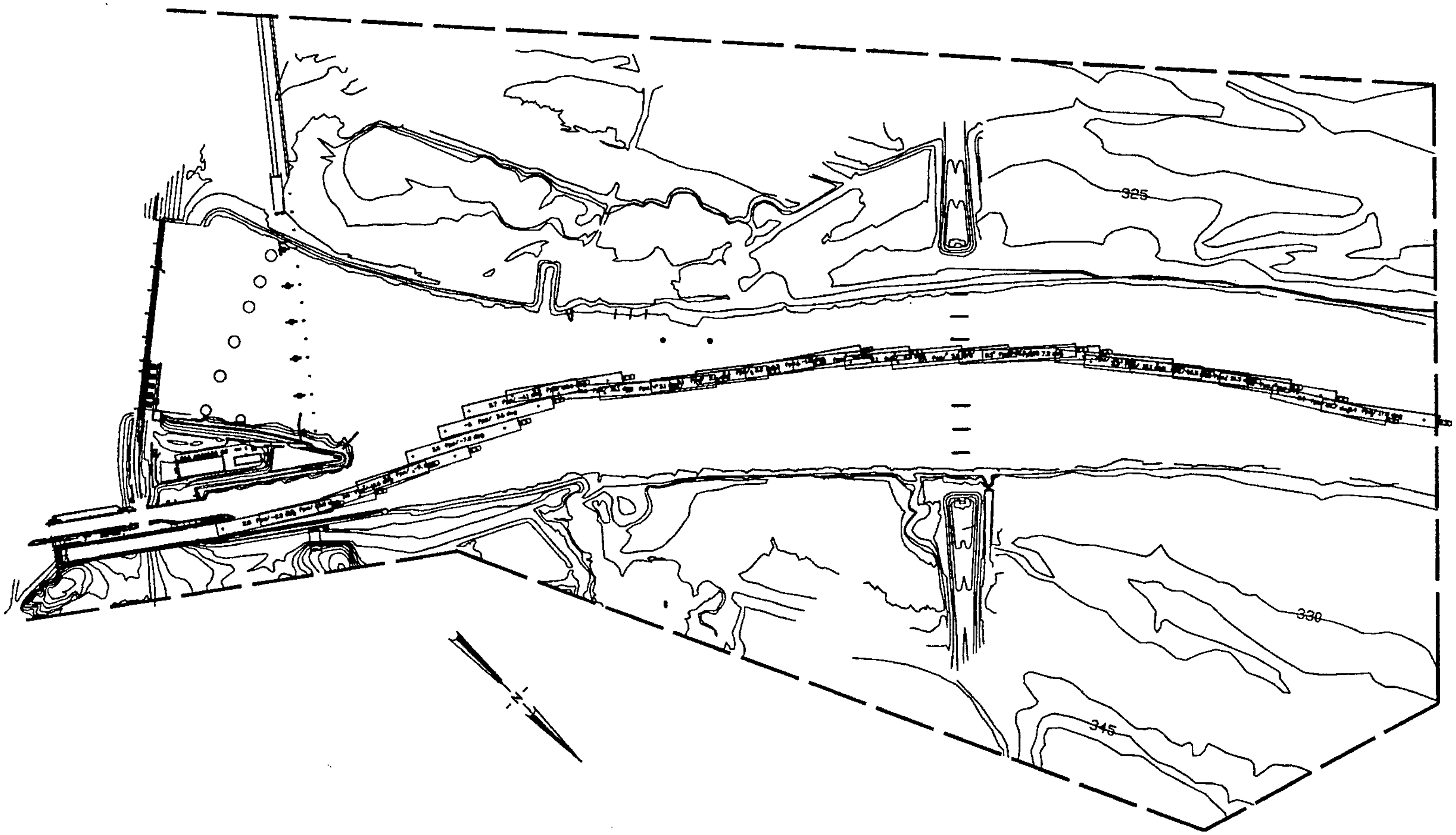
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–2, UPBOUND, OLD LOCK

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

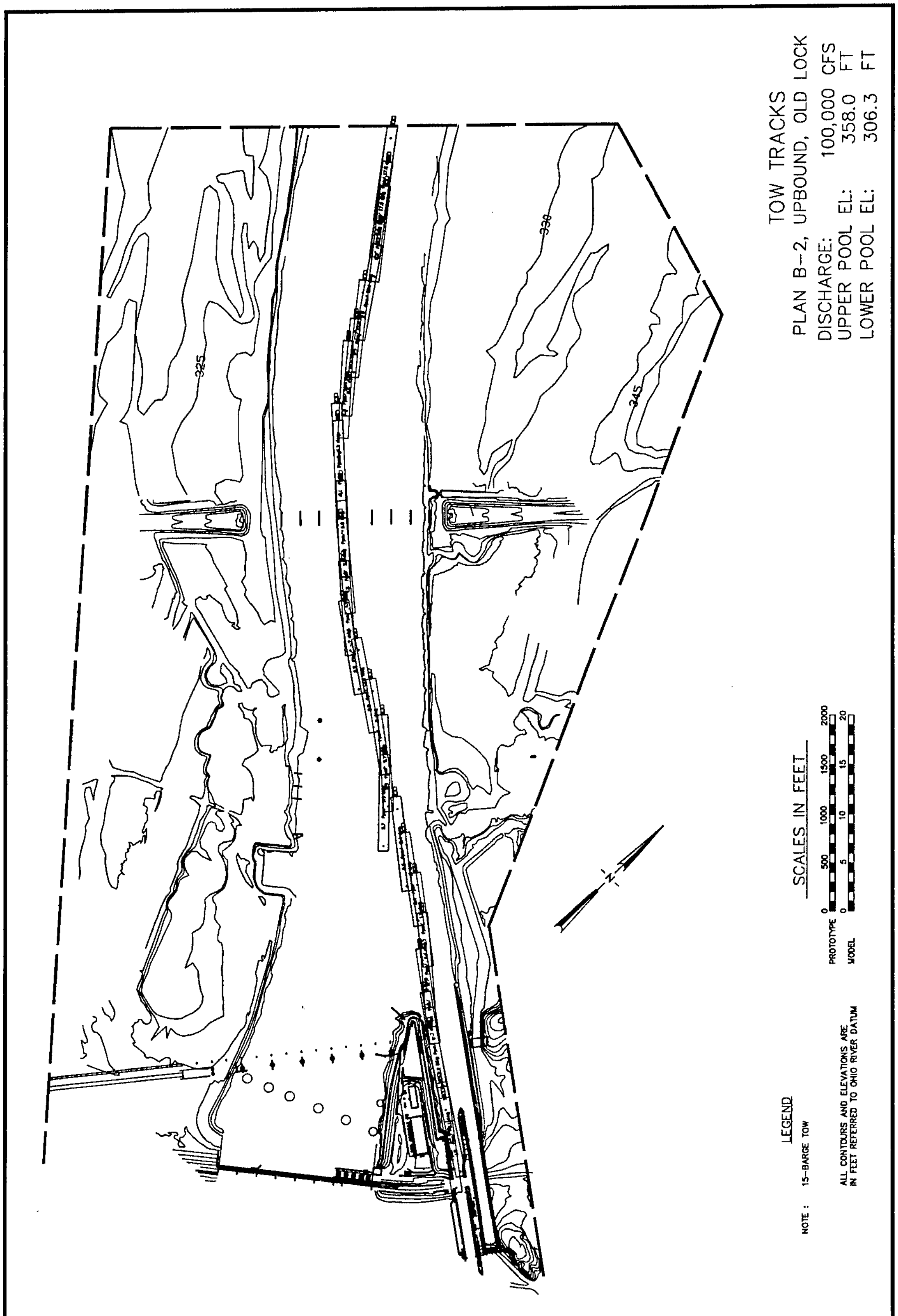
TOW TRACKS

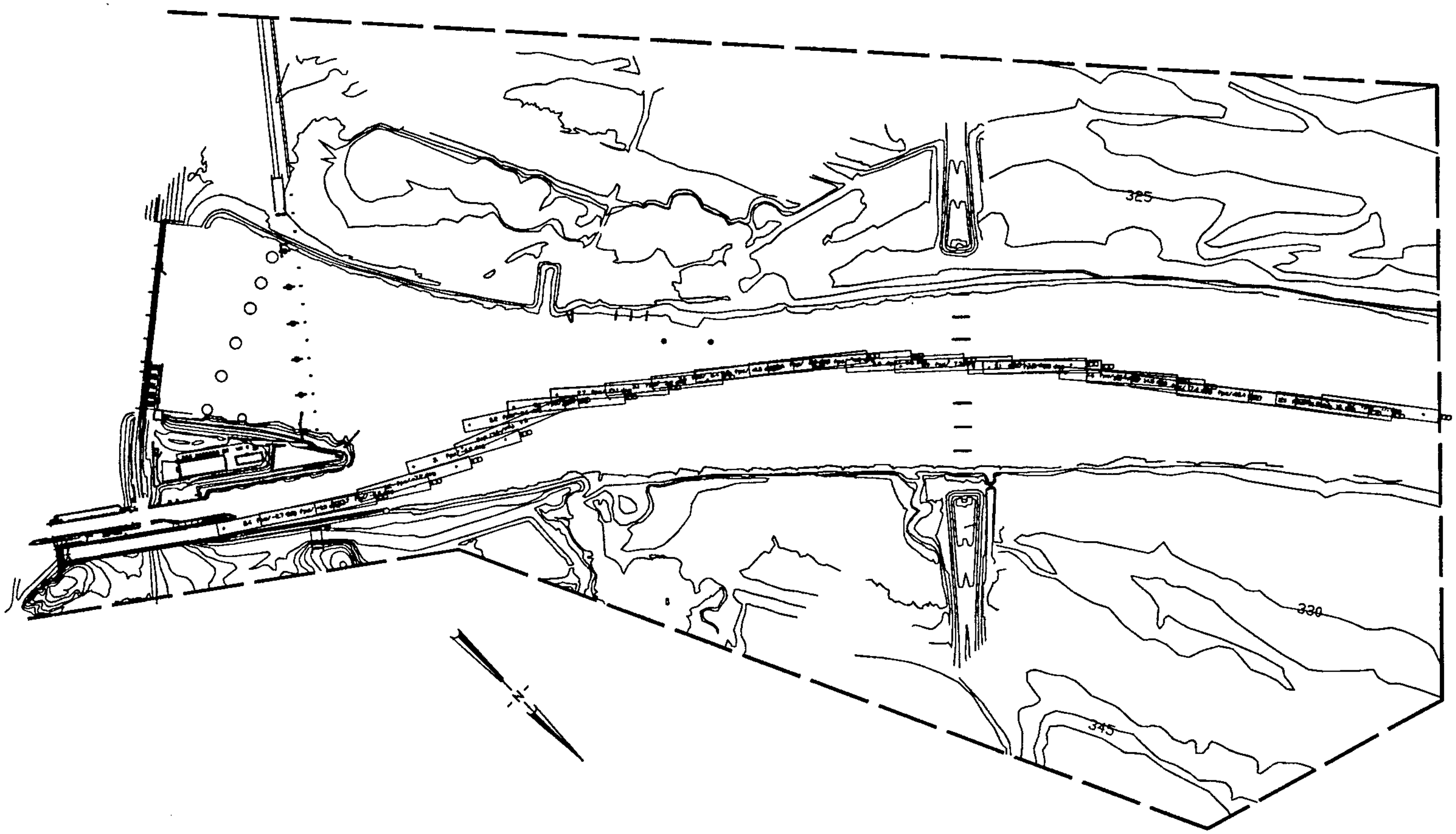
PLAN B-2, UPBOUND

DISCHARGE: 100,000 CFS

UPPER POOL EL: 358.0 FT

LOWER POOL EL: 303.6 FT


TOW TRACKS
PLAN B-2, UPBOUND, OLD LOCK
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT
325
338
345
N
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

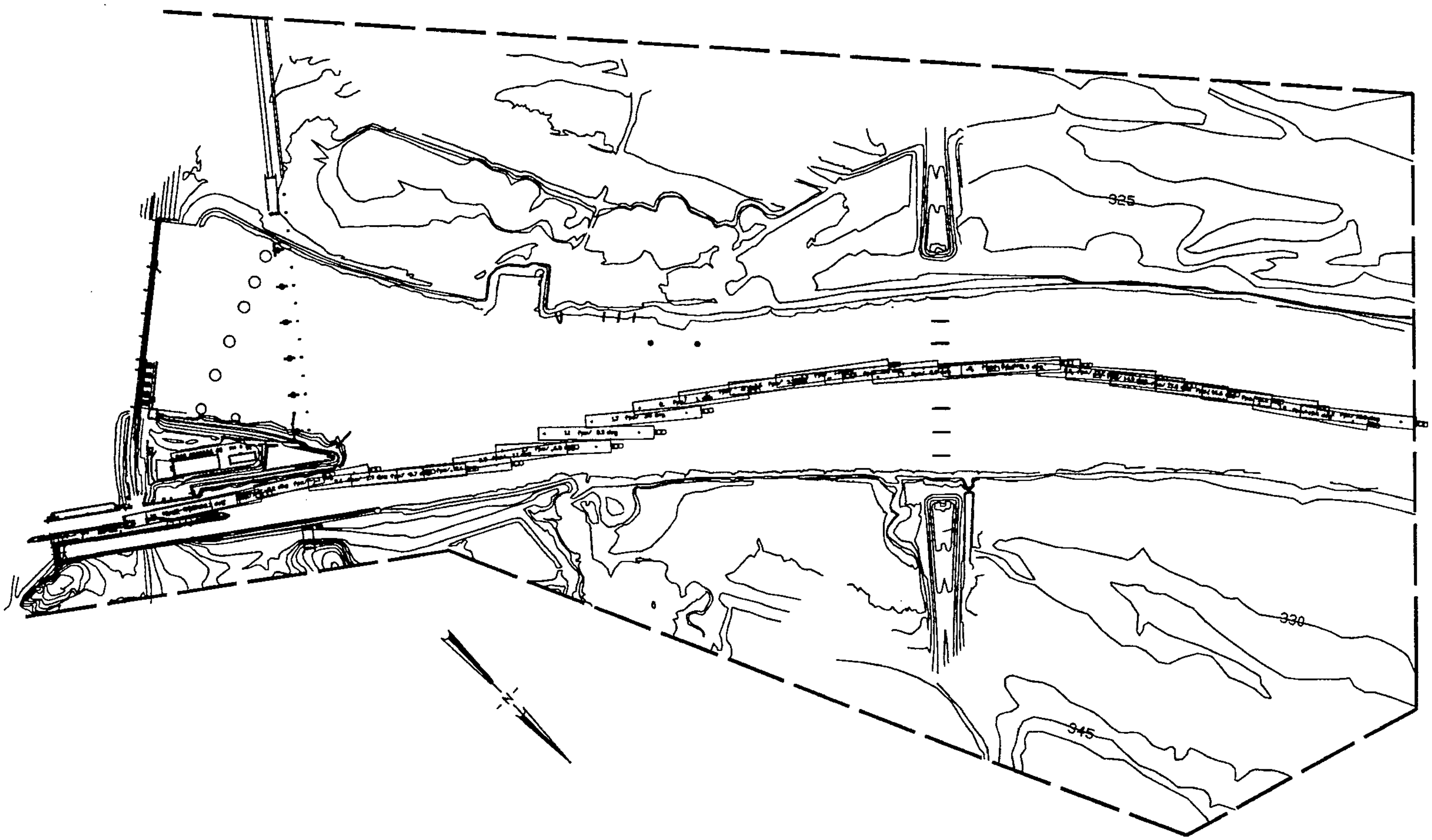
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–2, UPBOUND

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

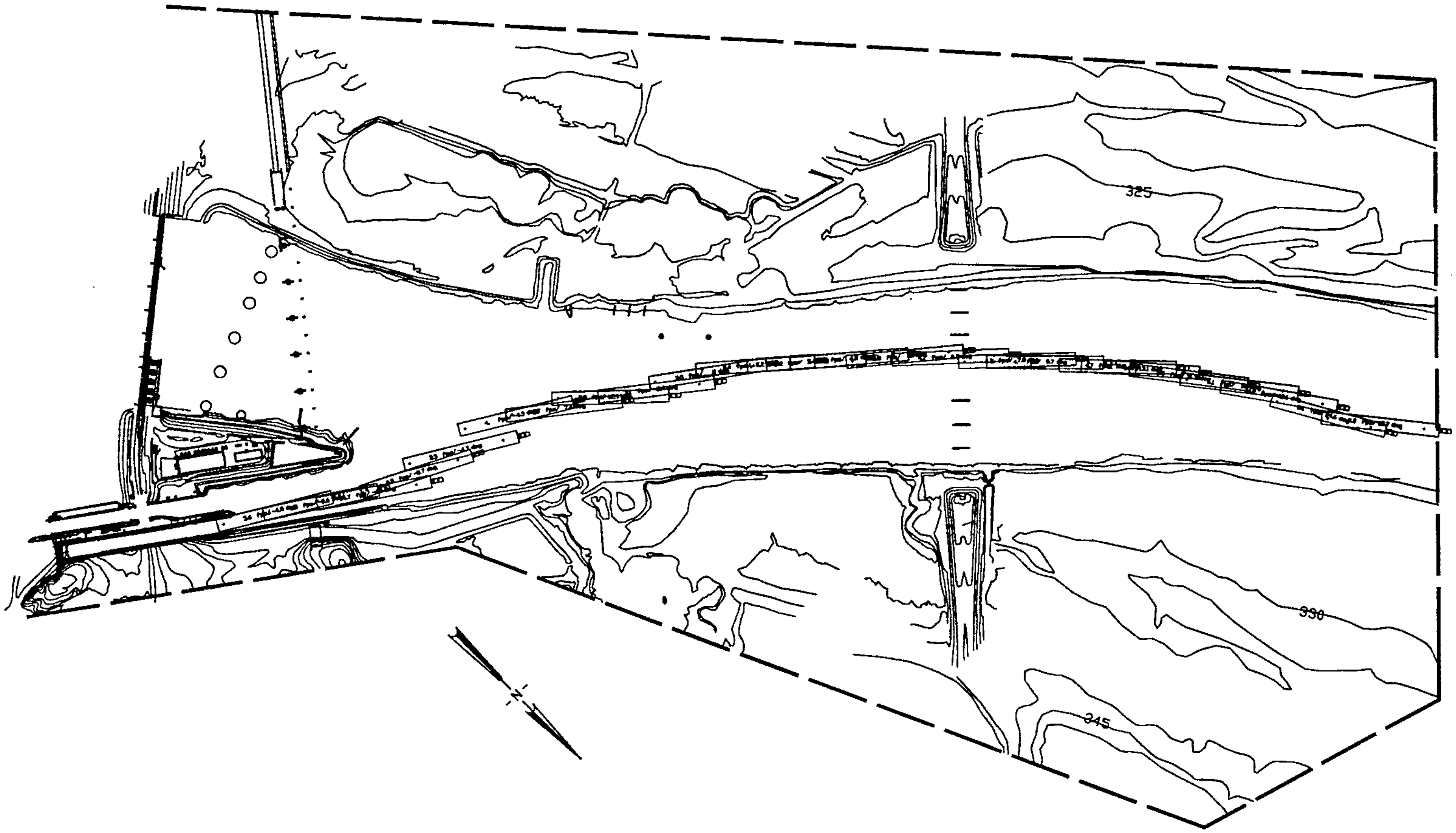
TOW TRACKS

PLAN B-2, UPBOUND, OLD LOCK

DISCHARGE: 155,000 CFS

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 316.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

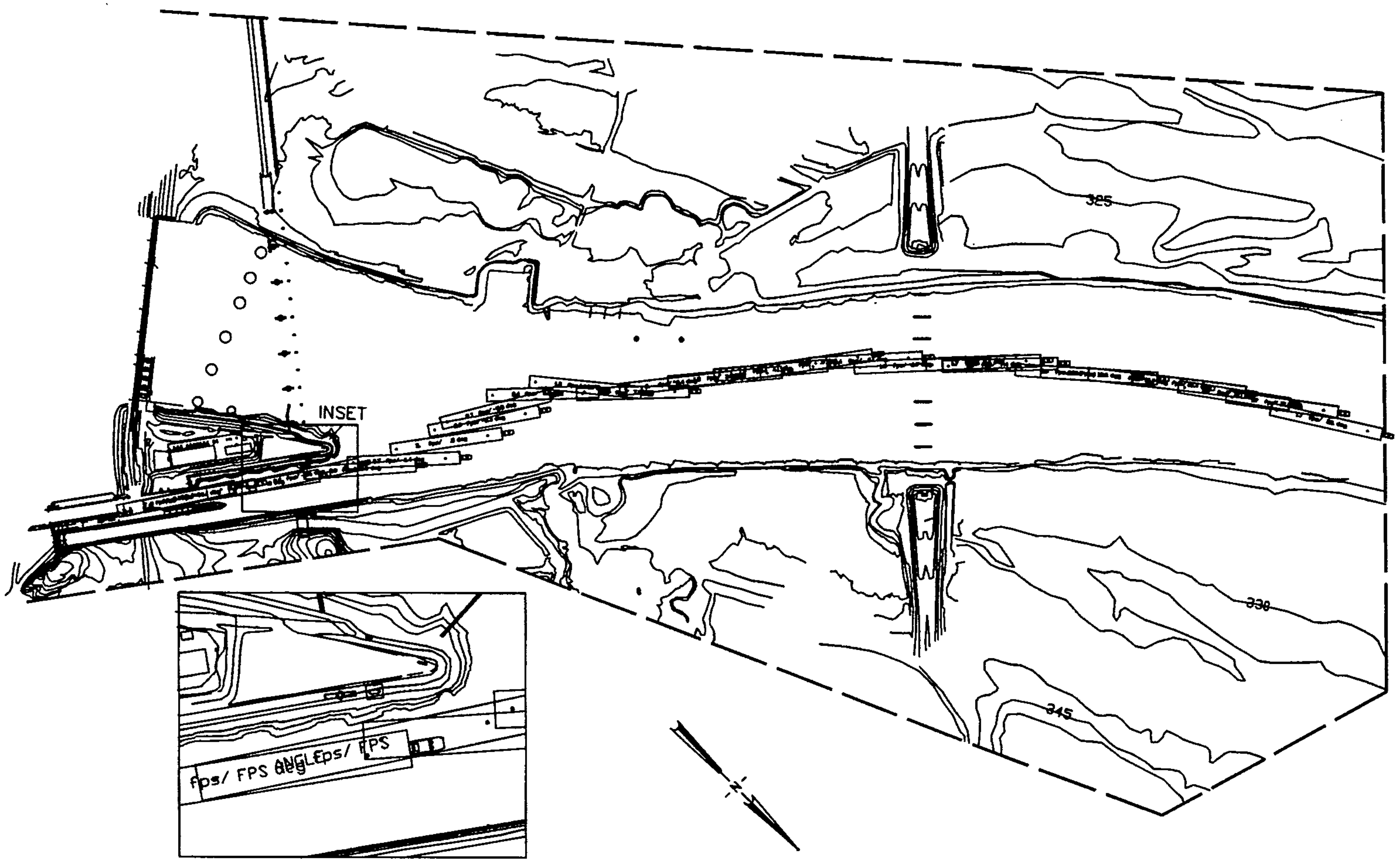
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, UPBOUND

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



INSET 3X

LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

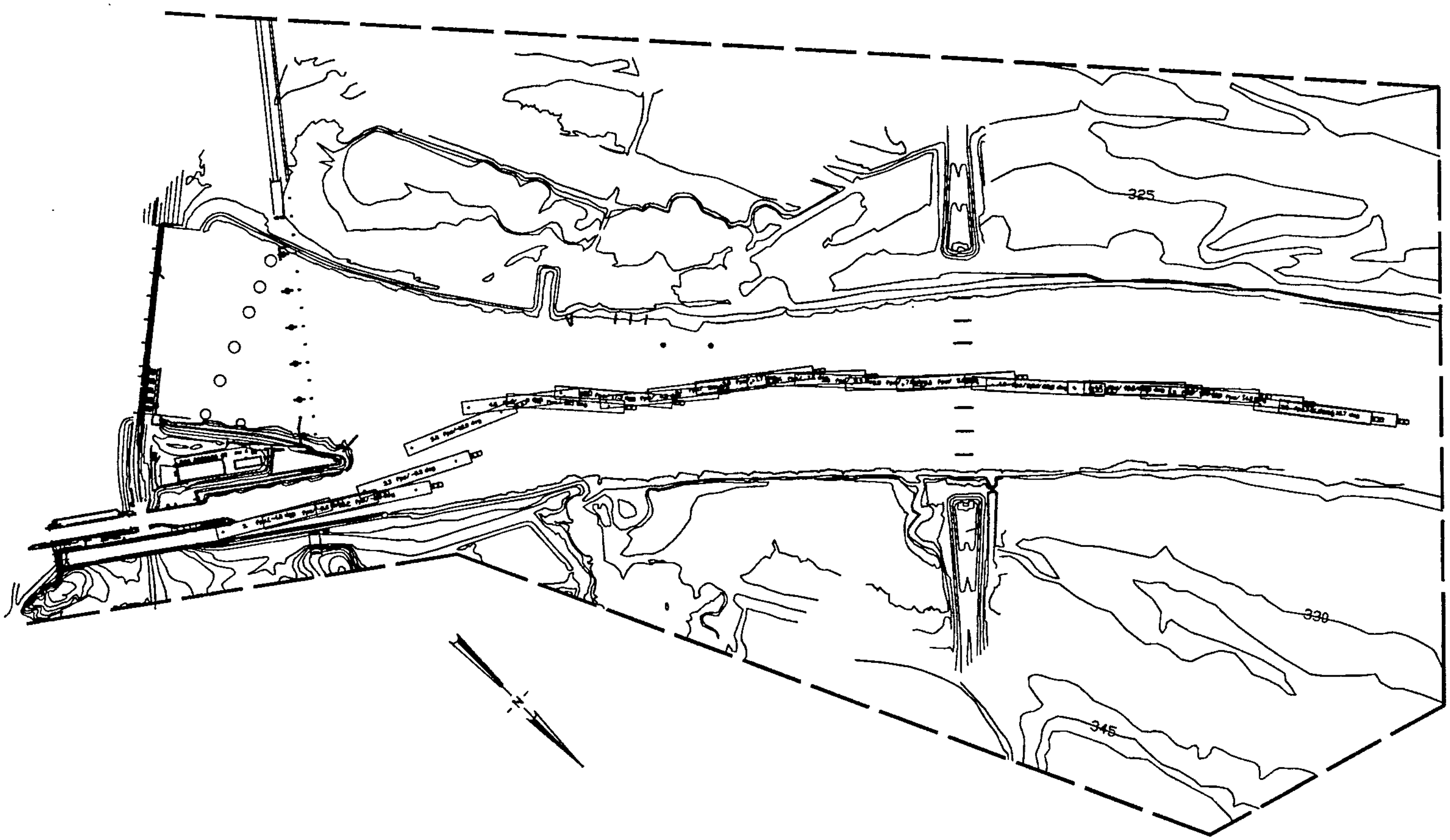
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, UPBOUND, OLD LOCK

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

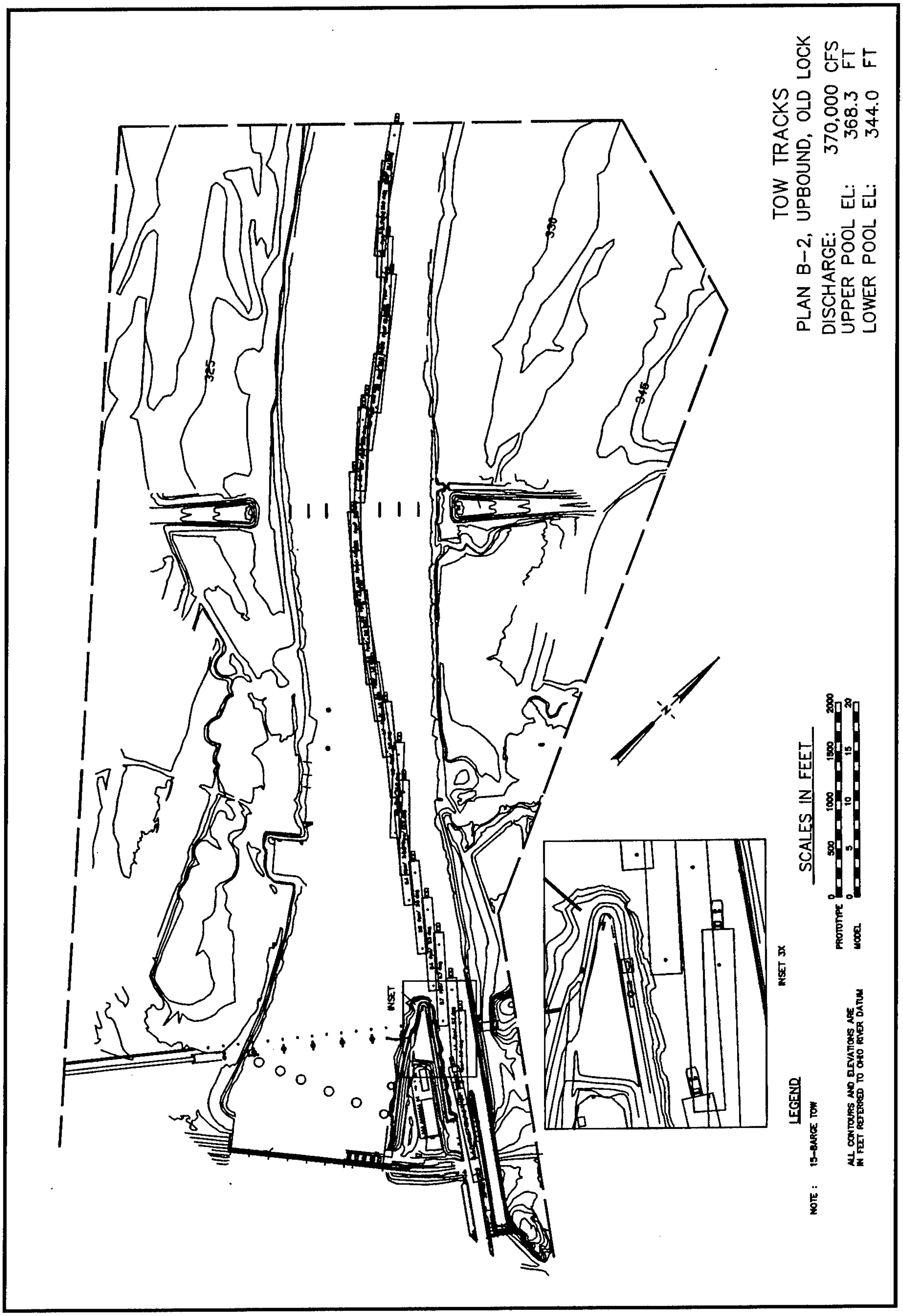
PROTOTYPE 0 500 1000 1500 2000

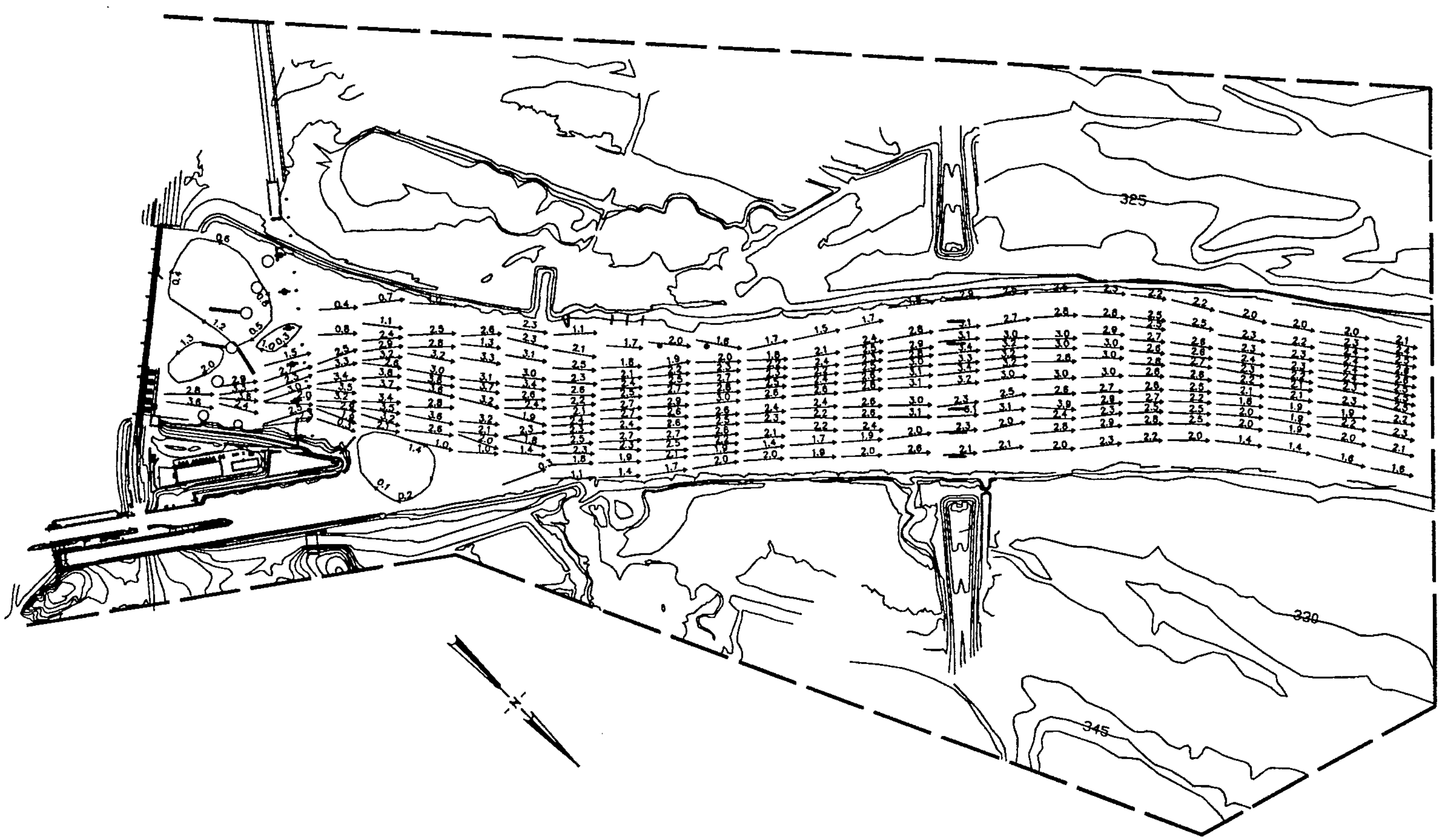
MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, UPBOUND

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT


TOW TRACKS
PLAN B-2, UPBOUND, OLD LOCK
DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
INSET
INSET 3X
325
330
345
N



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

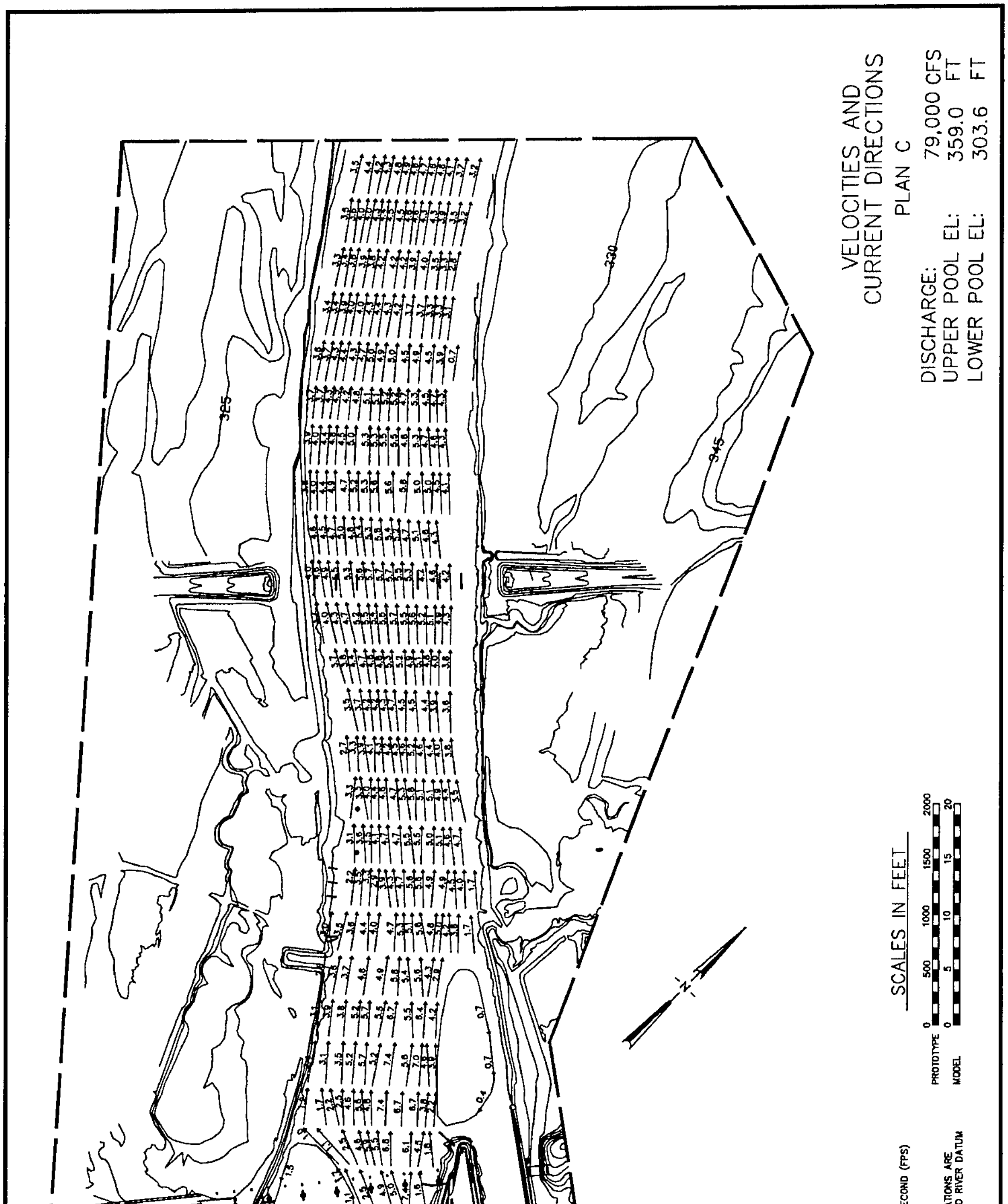
PROTOTYPE 0 500 1000 1500 2000

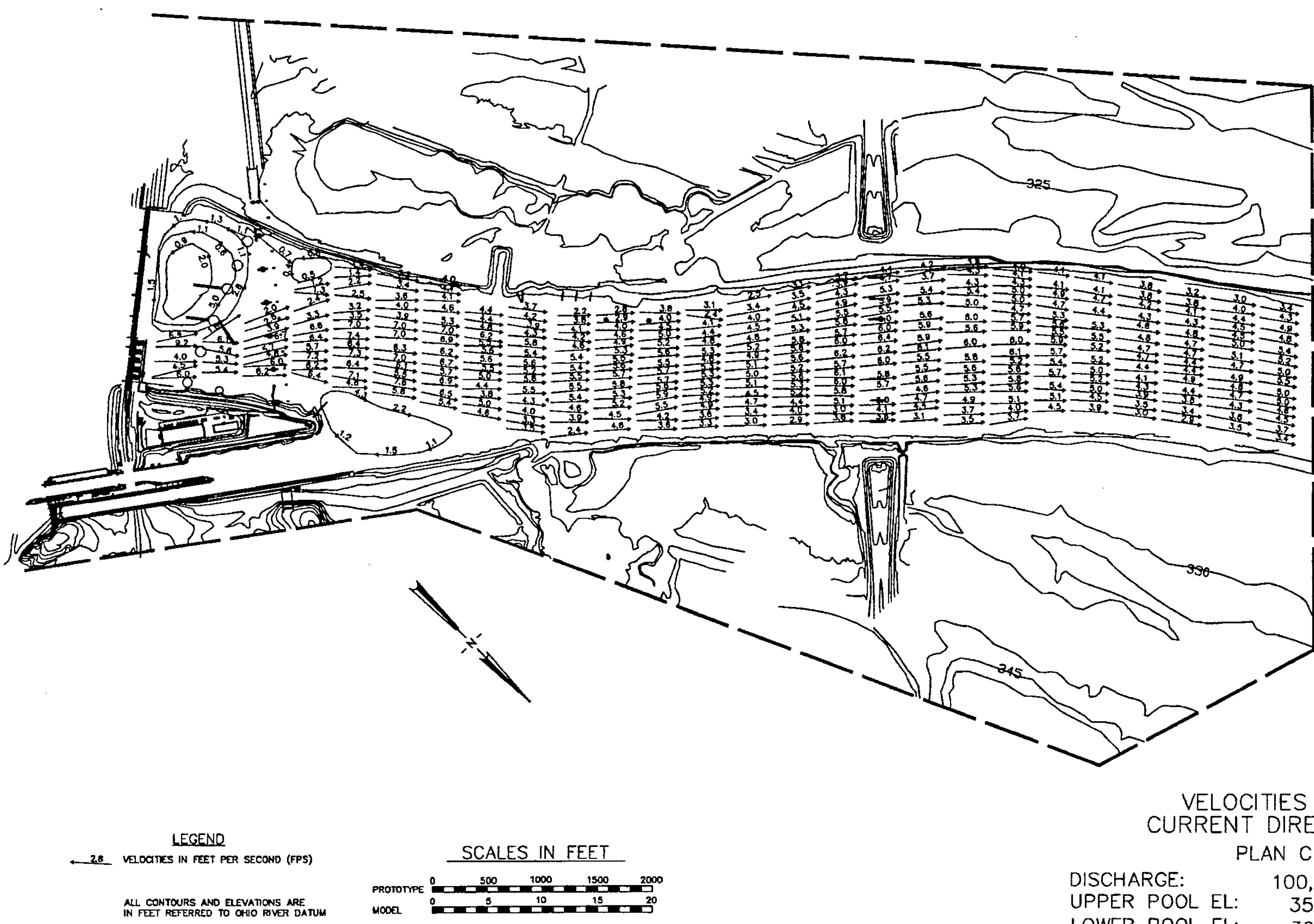
MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN C

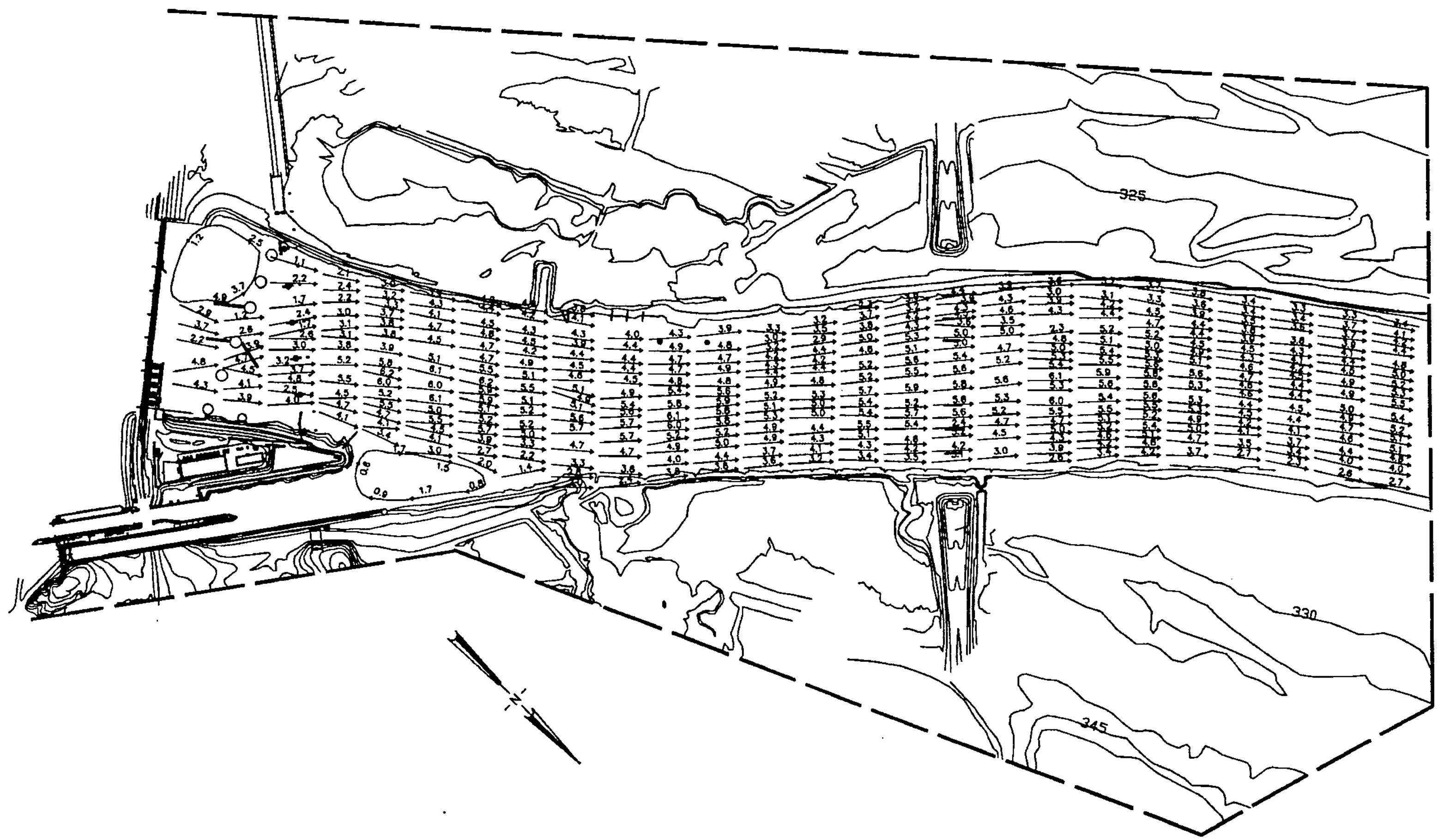
DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT


VELOCITIES AND CURRENT DIRECTIONS
PLAN C
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
N
325
330
345



VELOCITIES AND
CURRENT DIRECTIONS
PLAN C

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

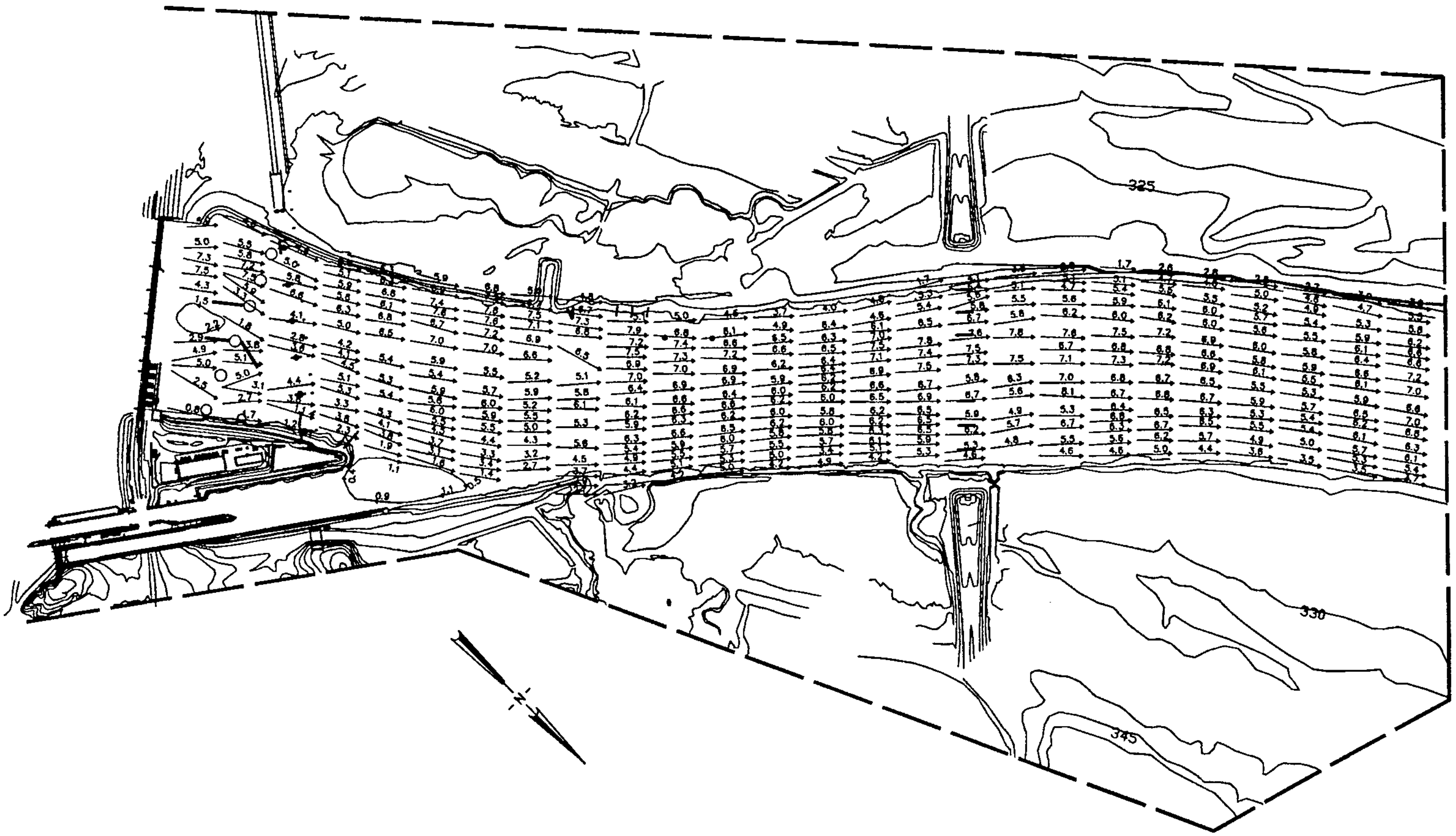
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

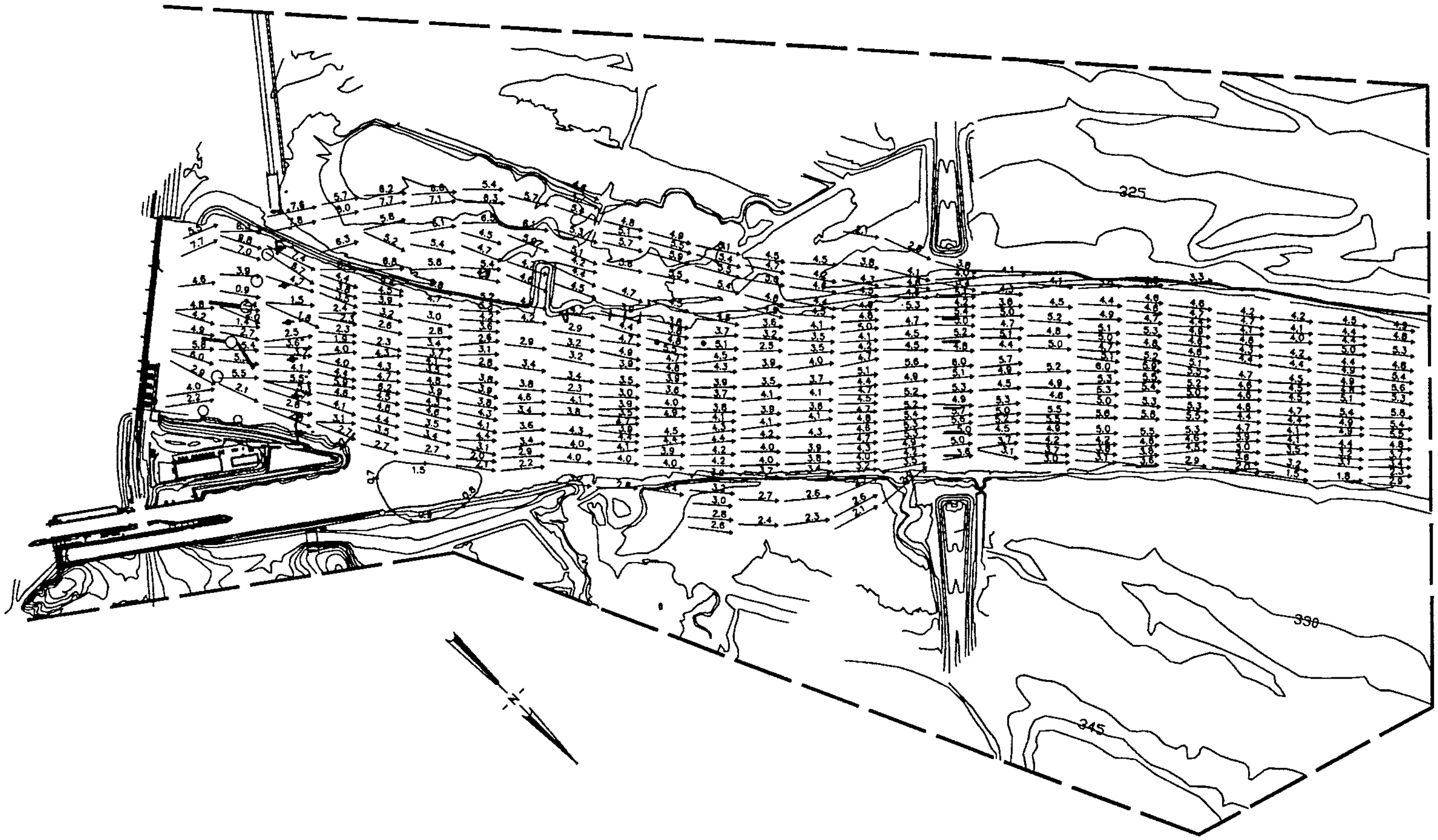
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

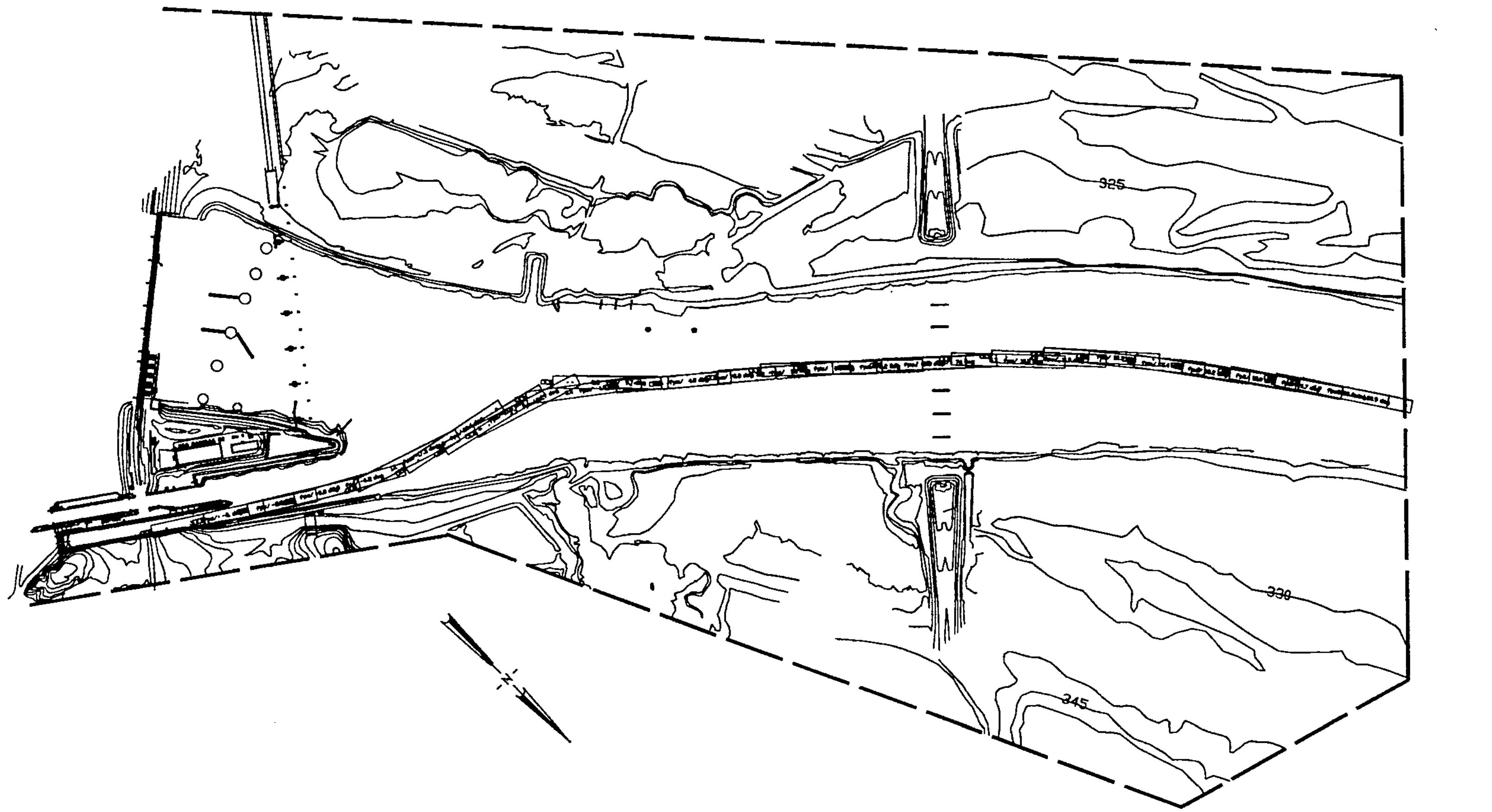
VELOCITIES AND CURRENT DIRECTIONS

PLAN C

DISCHARGE: 370,000 CFS

UPPER POOL EL: 368.3 FT

LOWER POOL EL: 344.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

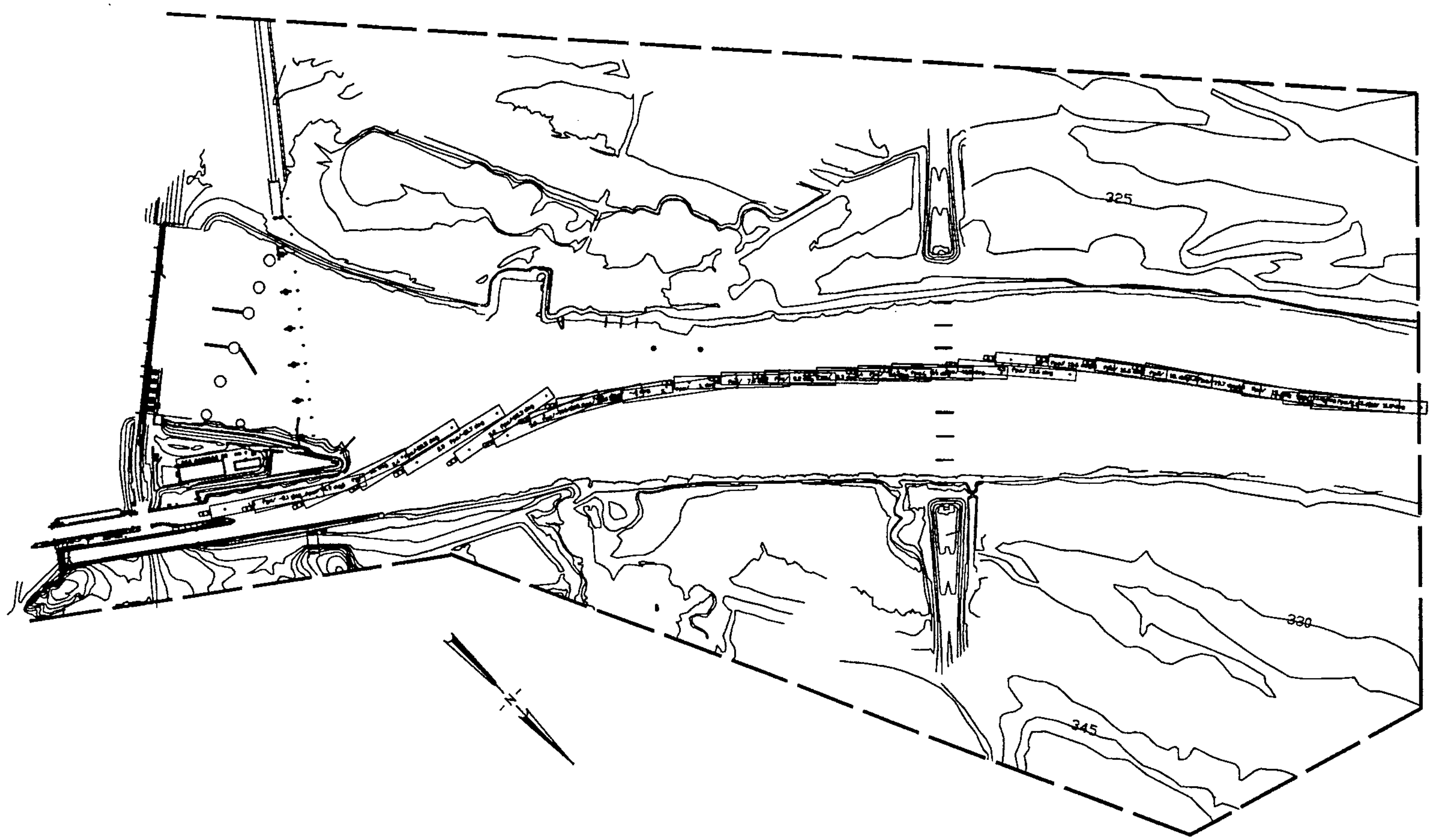
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

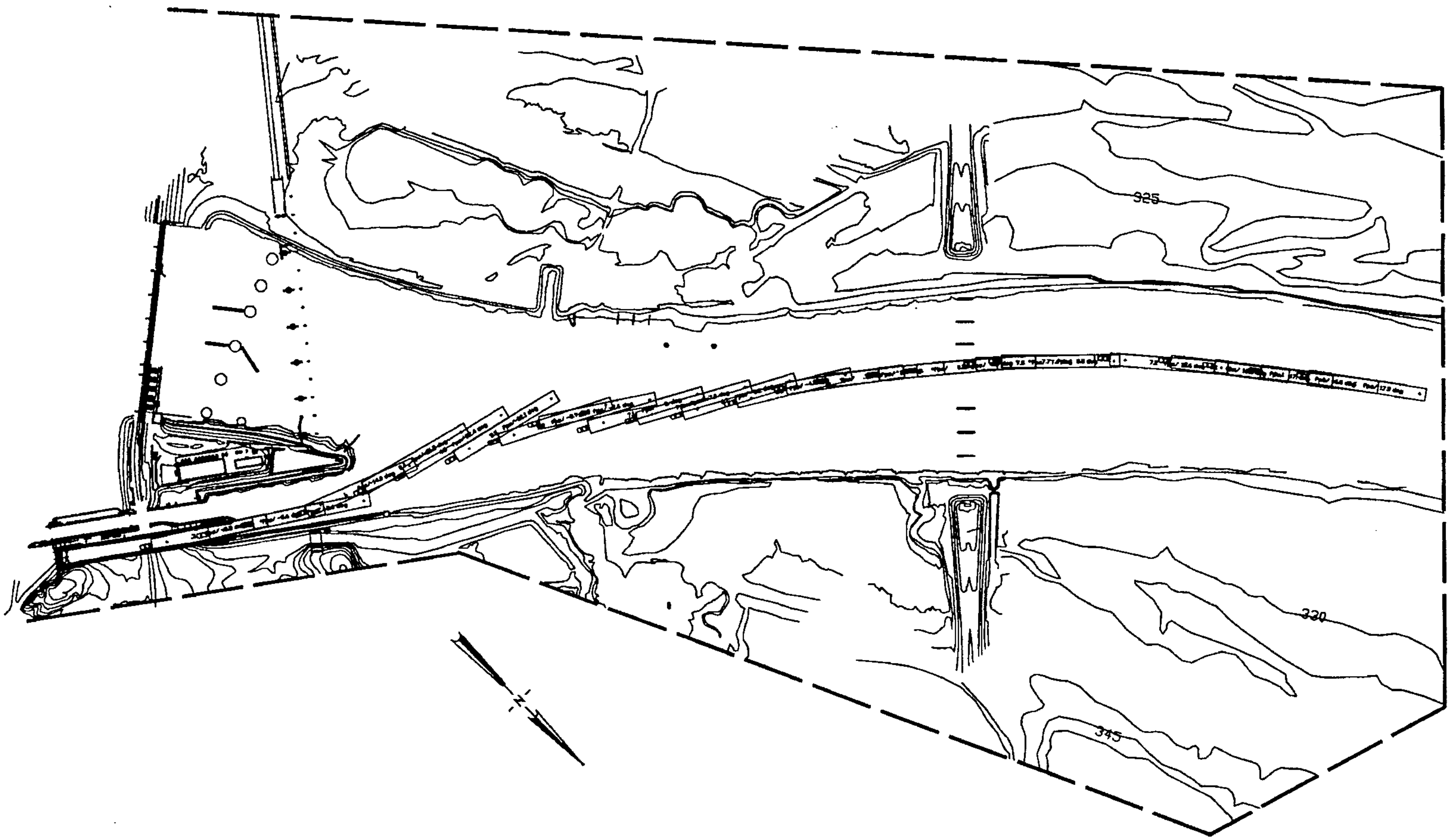
TOW TRACKS

PLAN C, DOWNBOUND, OLD LOCK

DISCHARGE: 35,000 CFS

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 300.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

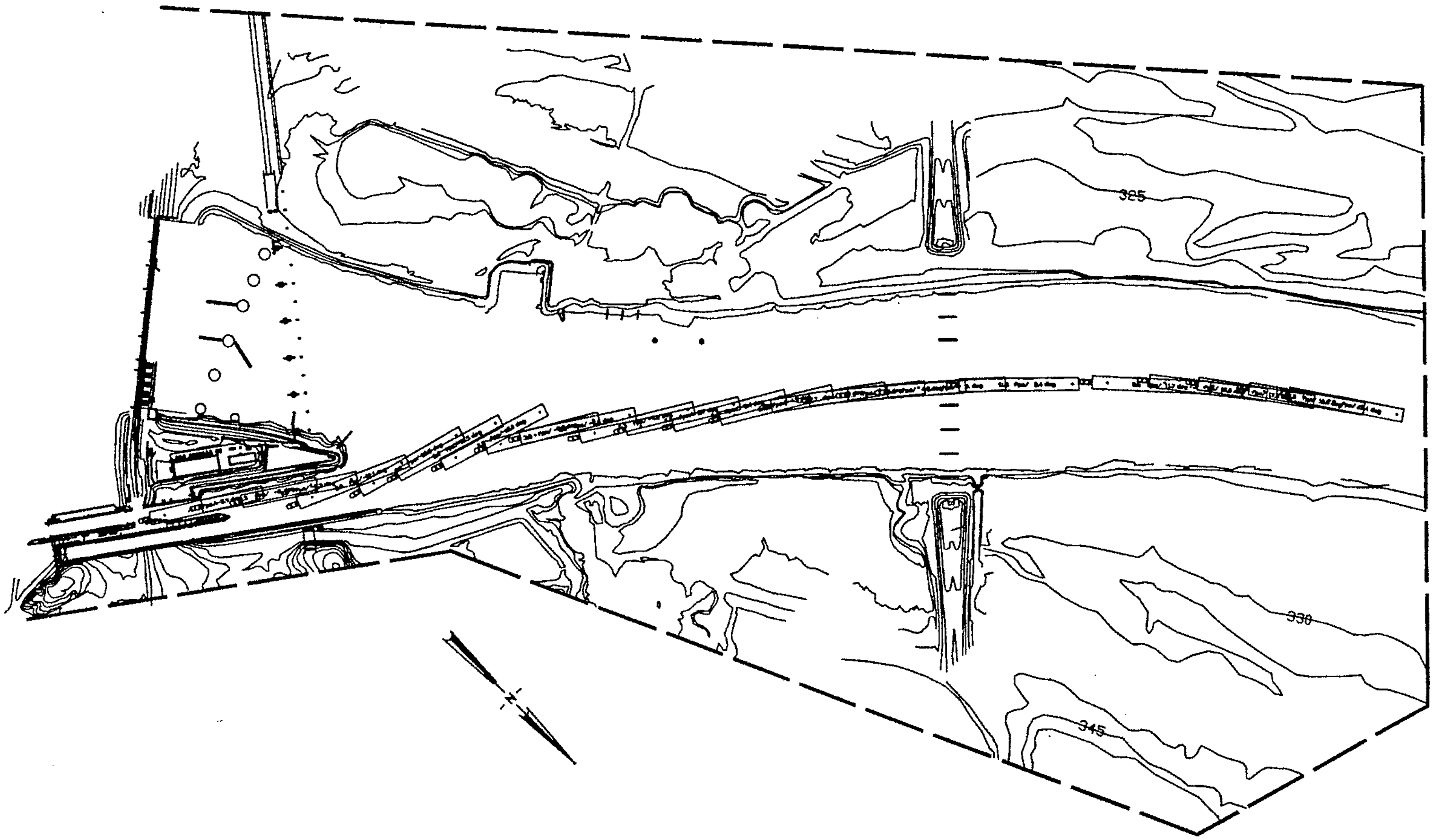
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, DOWNBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

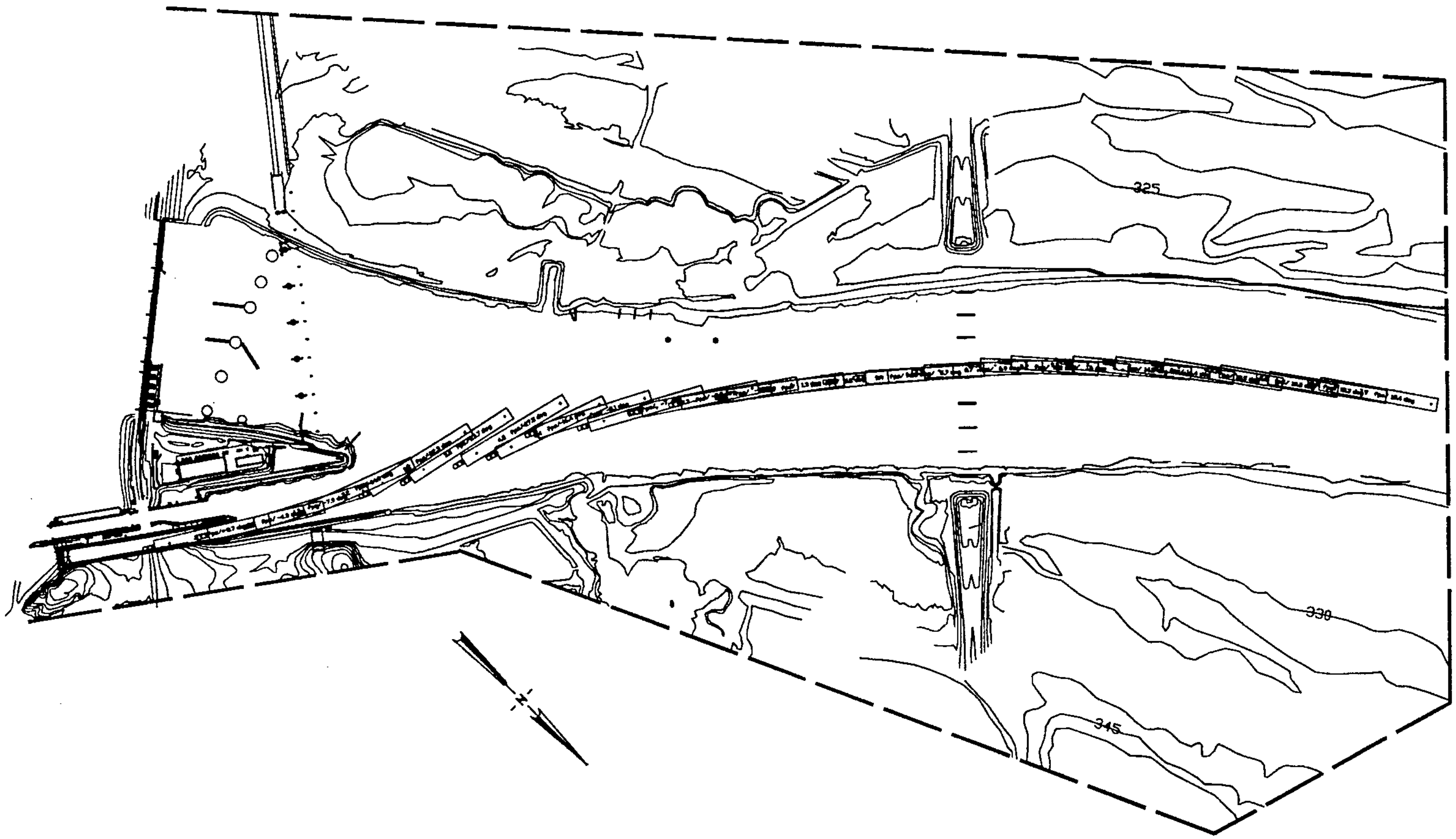
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, DOWNBOUND, OLD LOCK

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

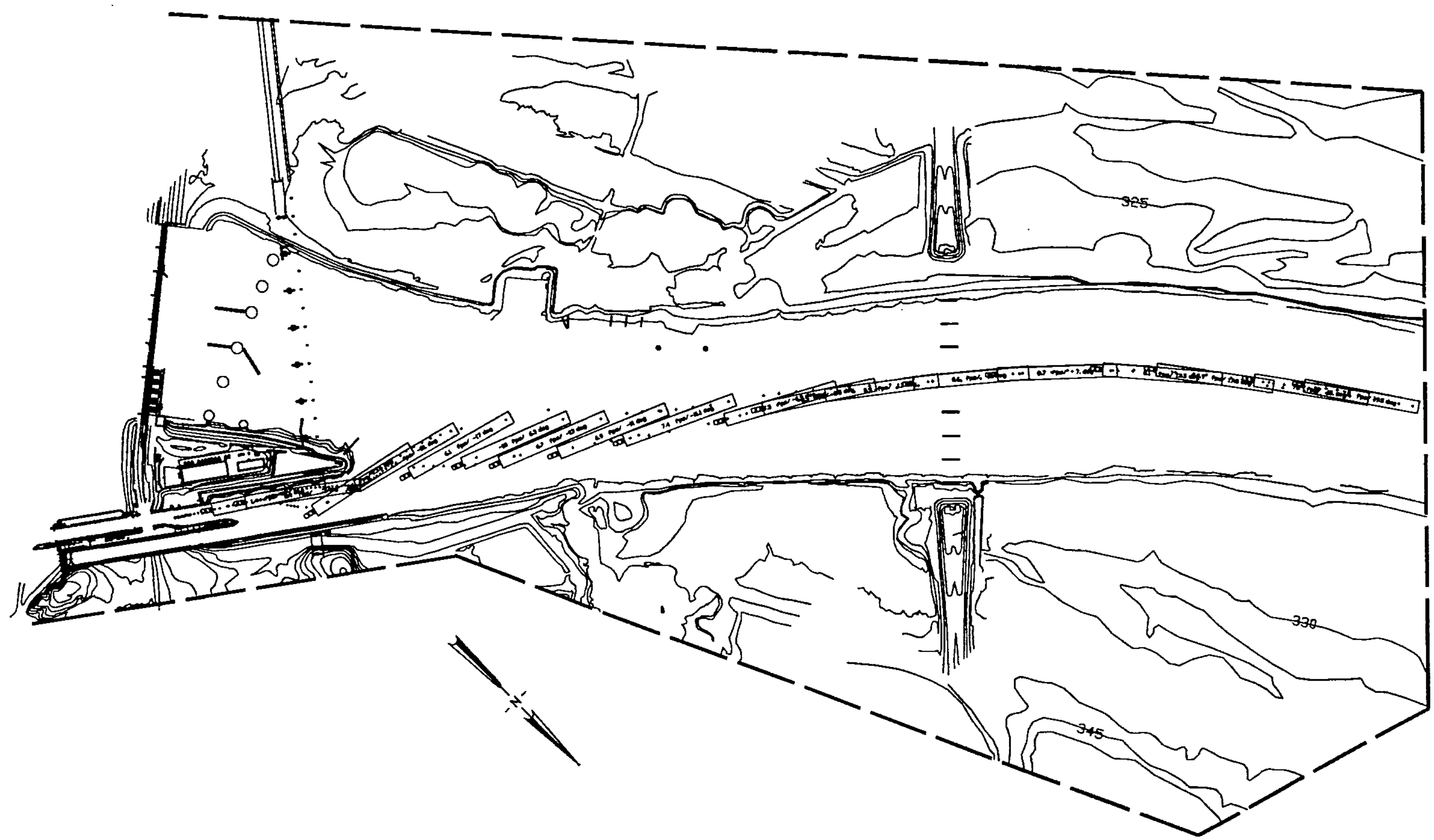
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, DOWNBOUND

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

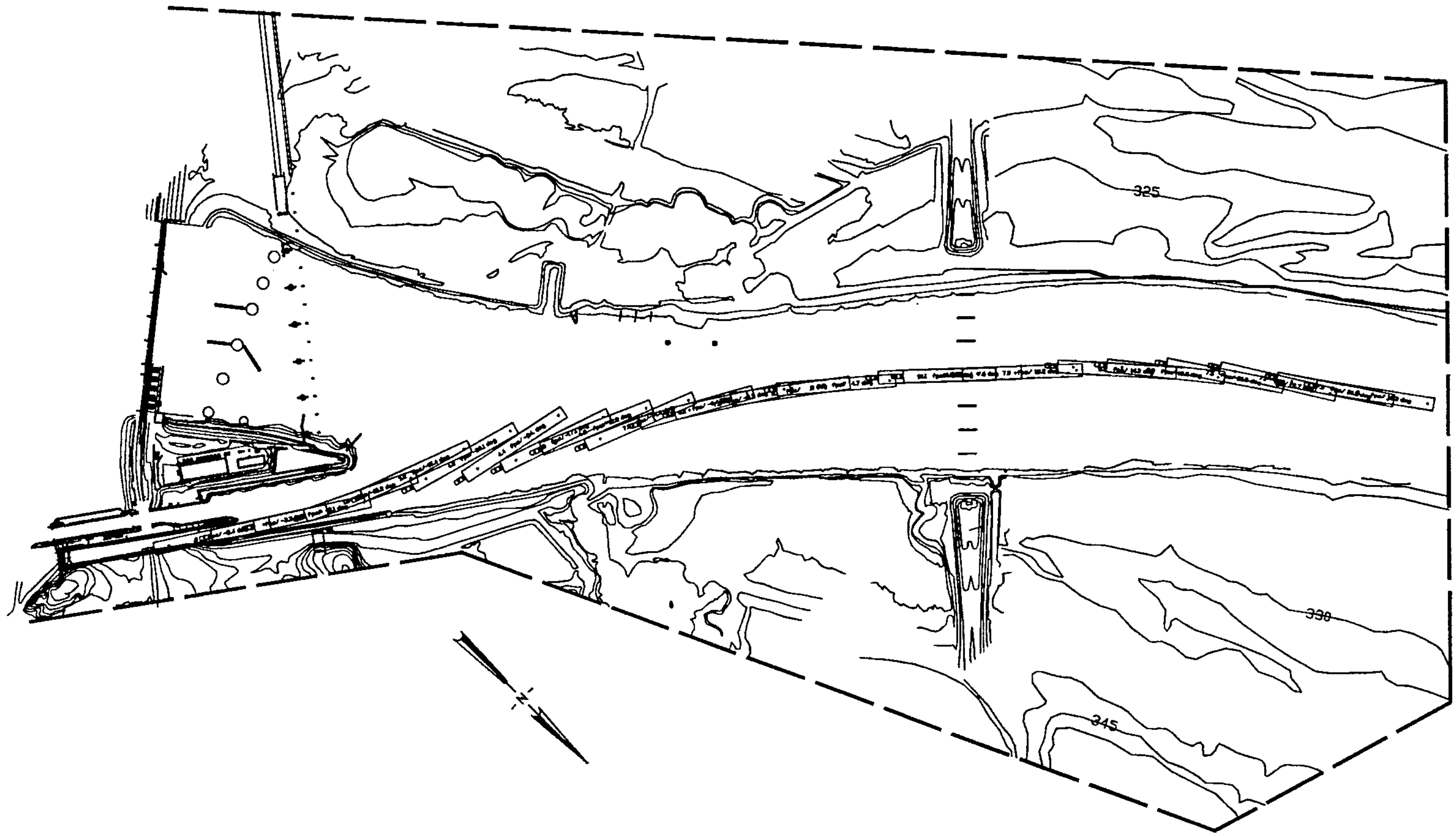
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, DOWNBOUND, OLD LOCK

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



LEGEND

NOTE : 15-BARGE TOW

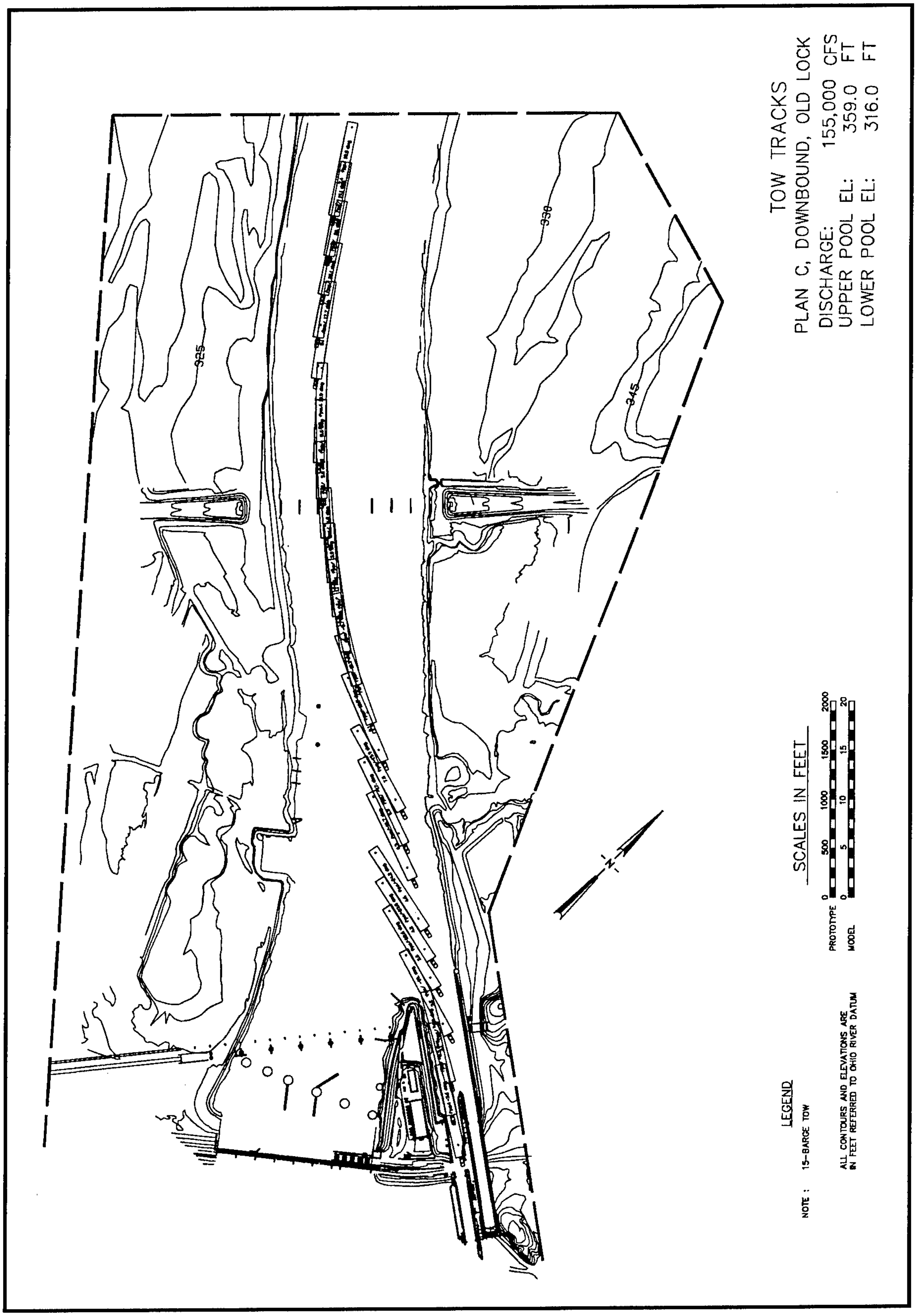
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

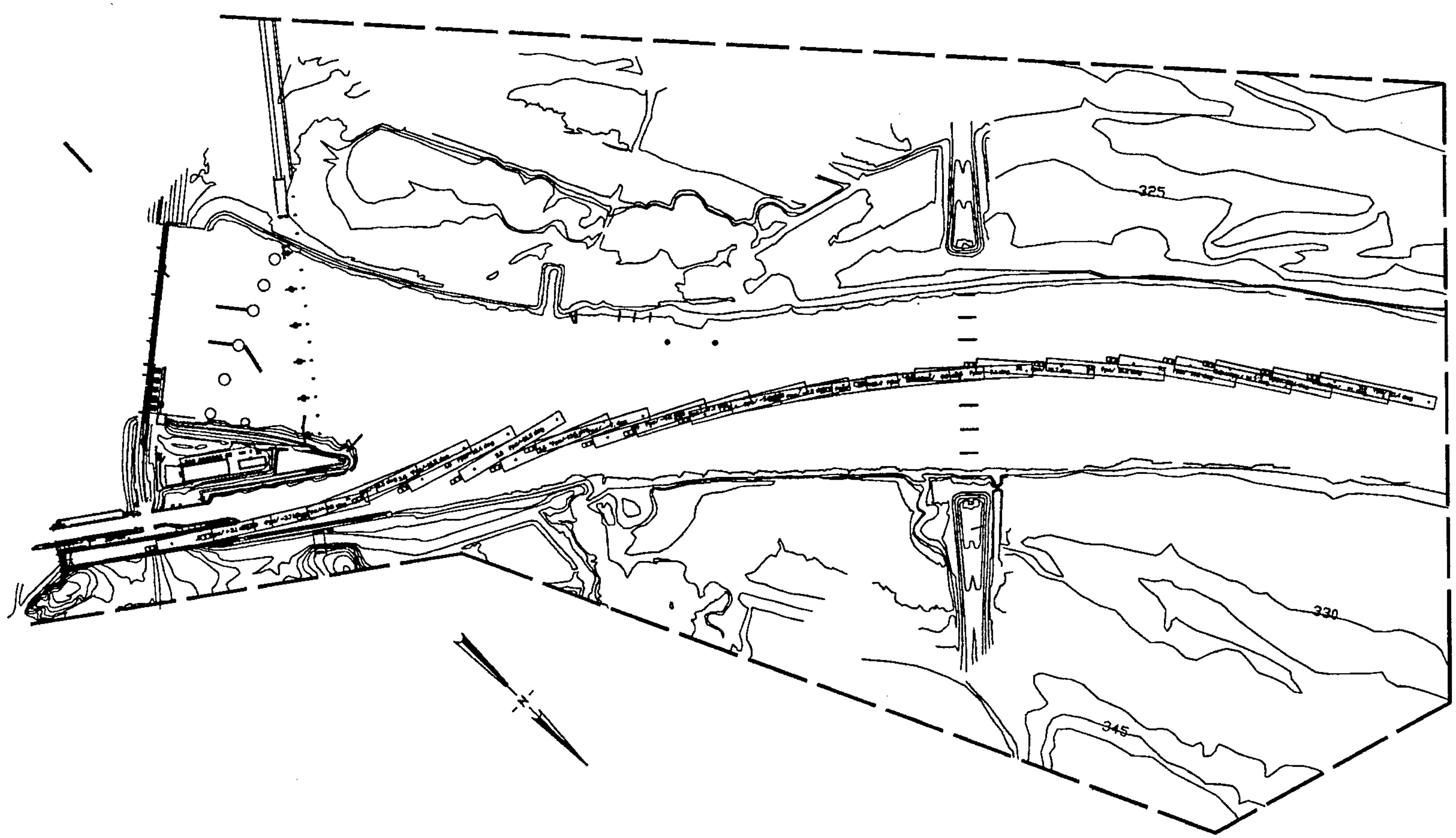
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN C, DOWNBOUND

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT


TOW TRACKS
PLAN C, DOWNBOUND, OLD LOCK
DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT
325
330
345
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
N
LEGEND
15-BARGE TOW
NOTE : ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

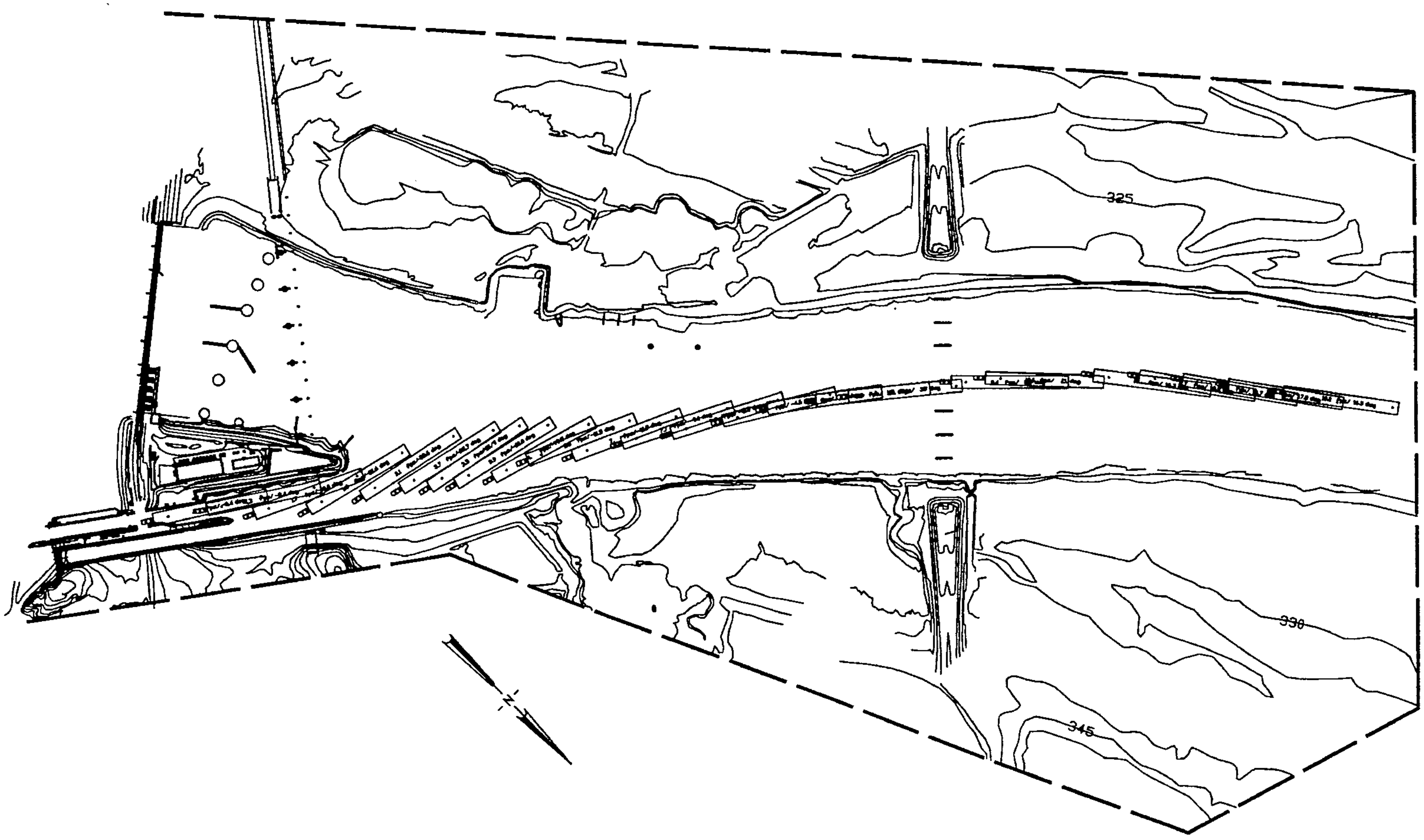
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

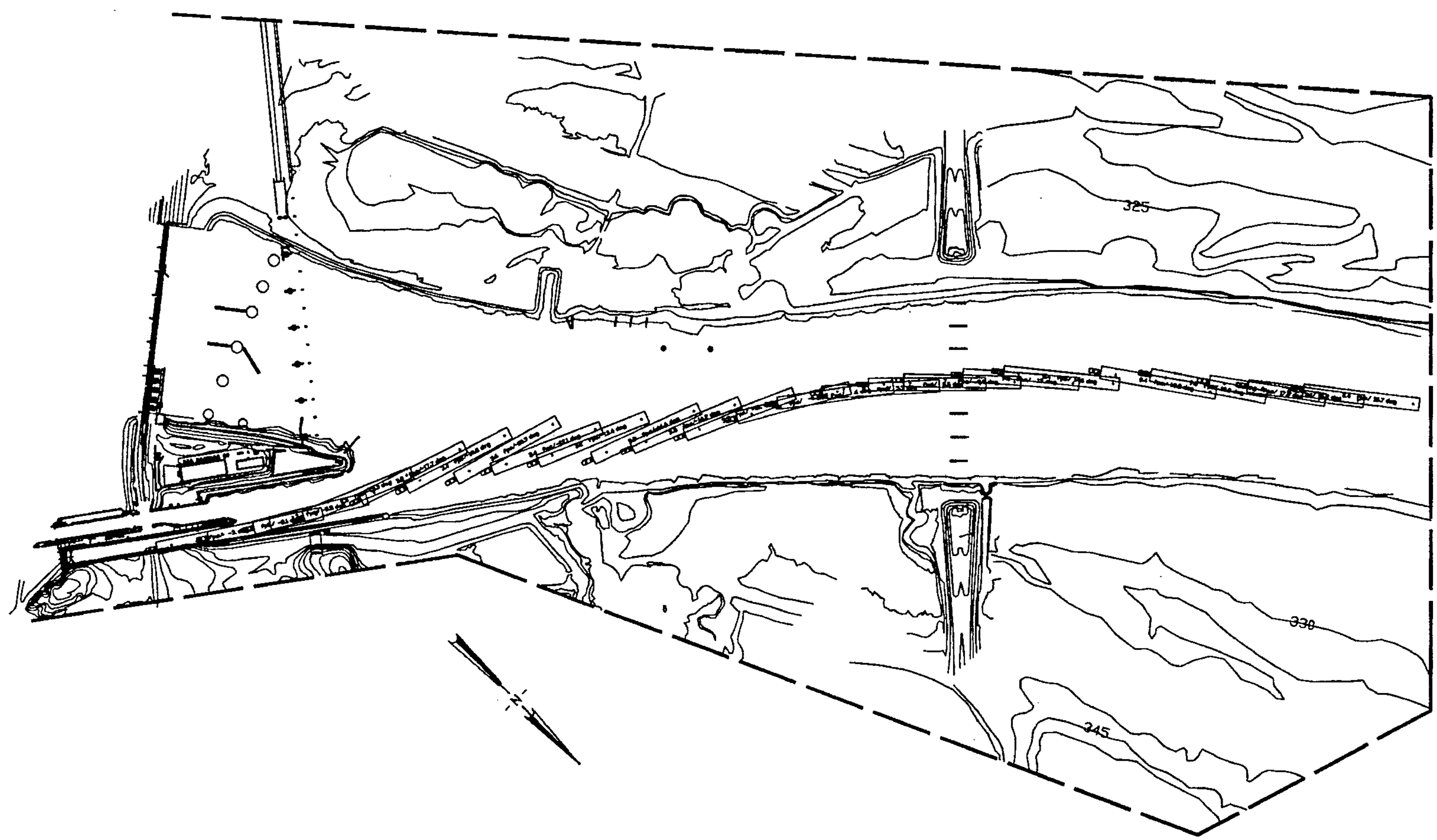
MODEL 0 5 10 15 20

TOW TRACKS
PLAN C, DOWNBOUND

DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT



325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN C, DOWNBOUND, OLD LOCK
DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

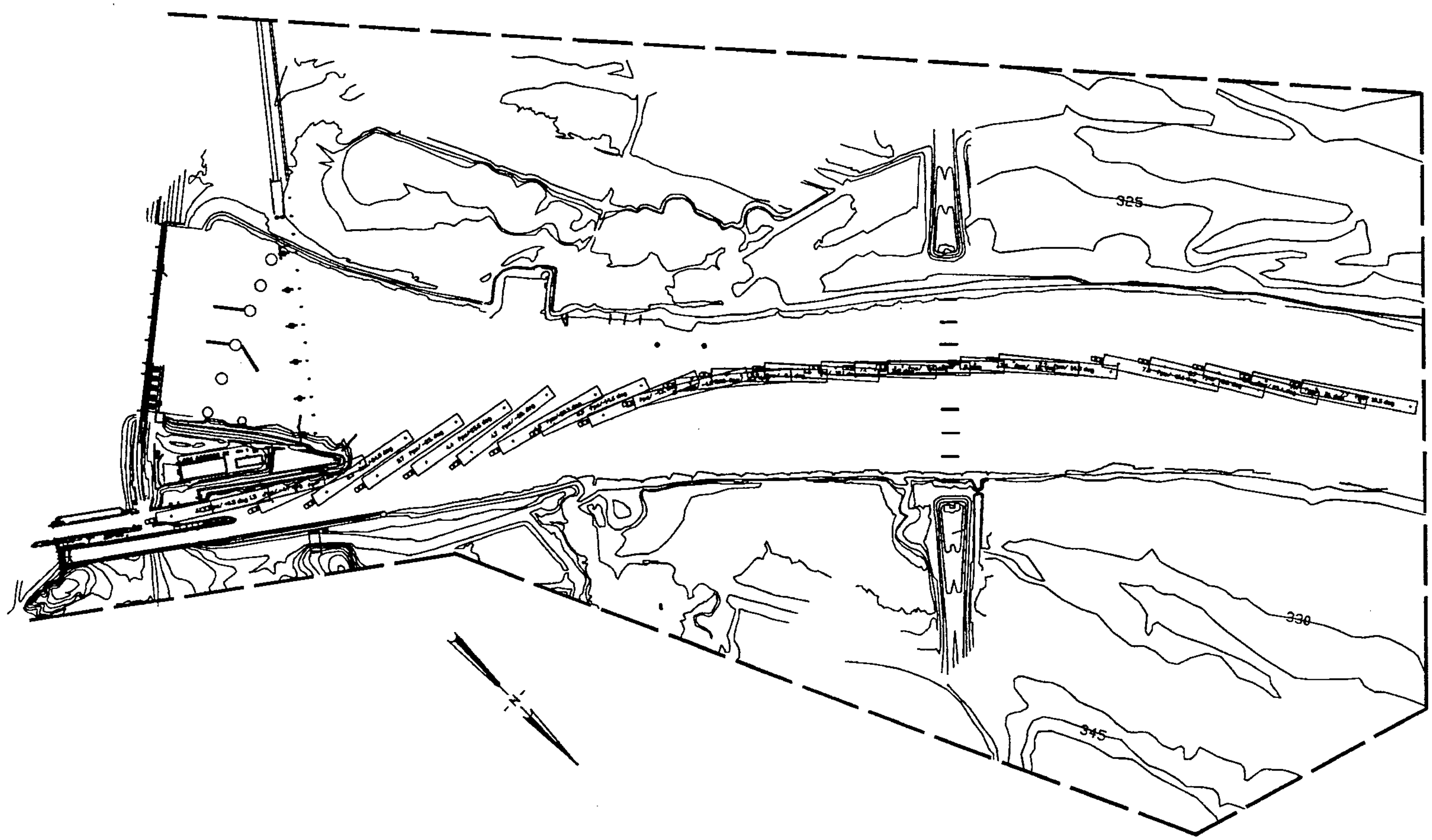
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
PLAN C, DOWNBOUND

DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

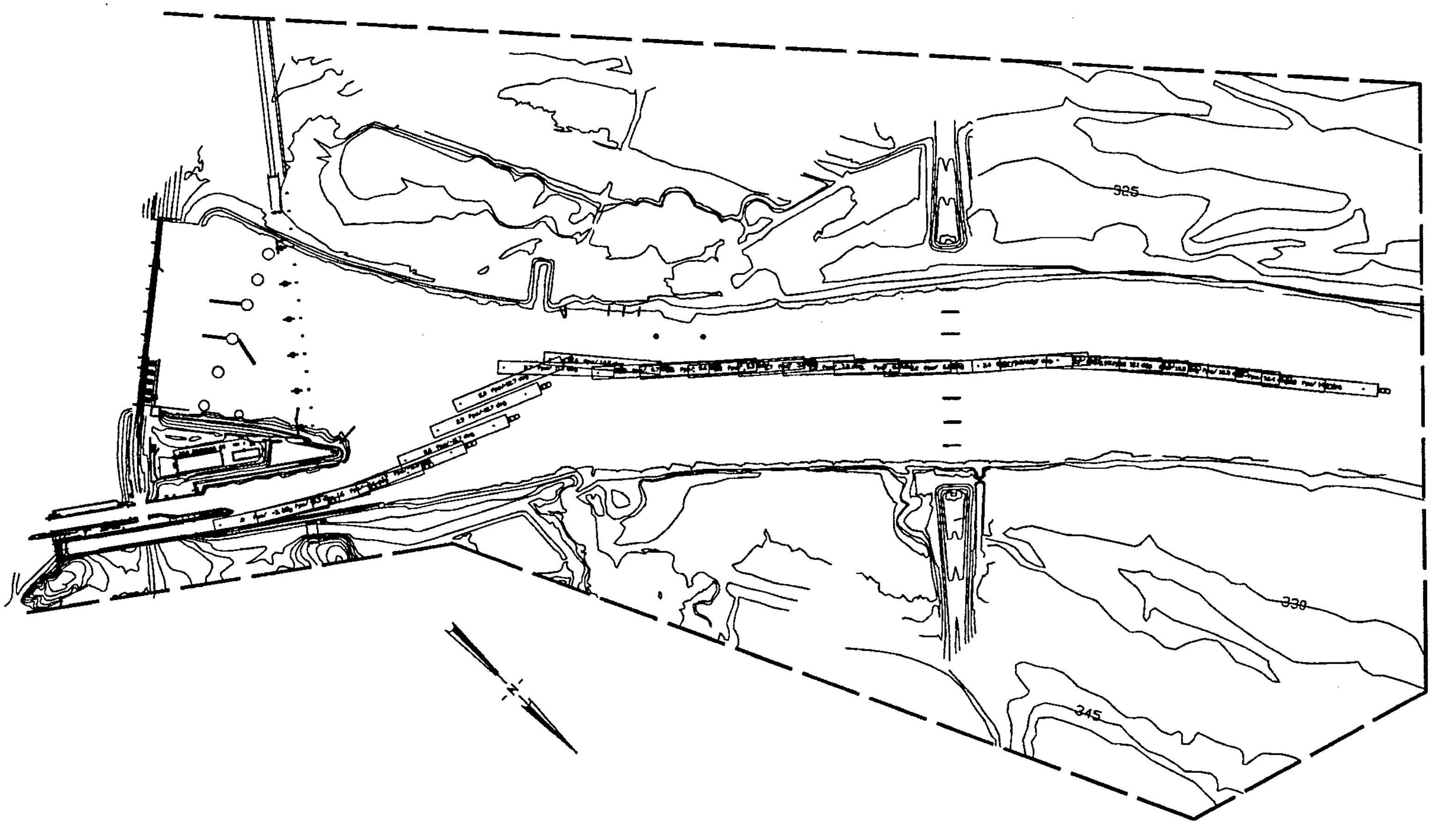
TOW TRACKS

PLAN C, DOWNBOUND, OLD LOCK

DISCHARGE: 370,000 CFS

UPPER POOL EL: 368.3 FT

LOWER POOL EL: 344.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

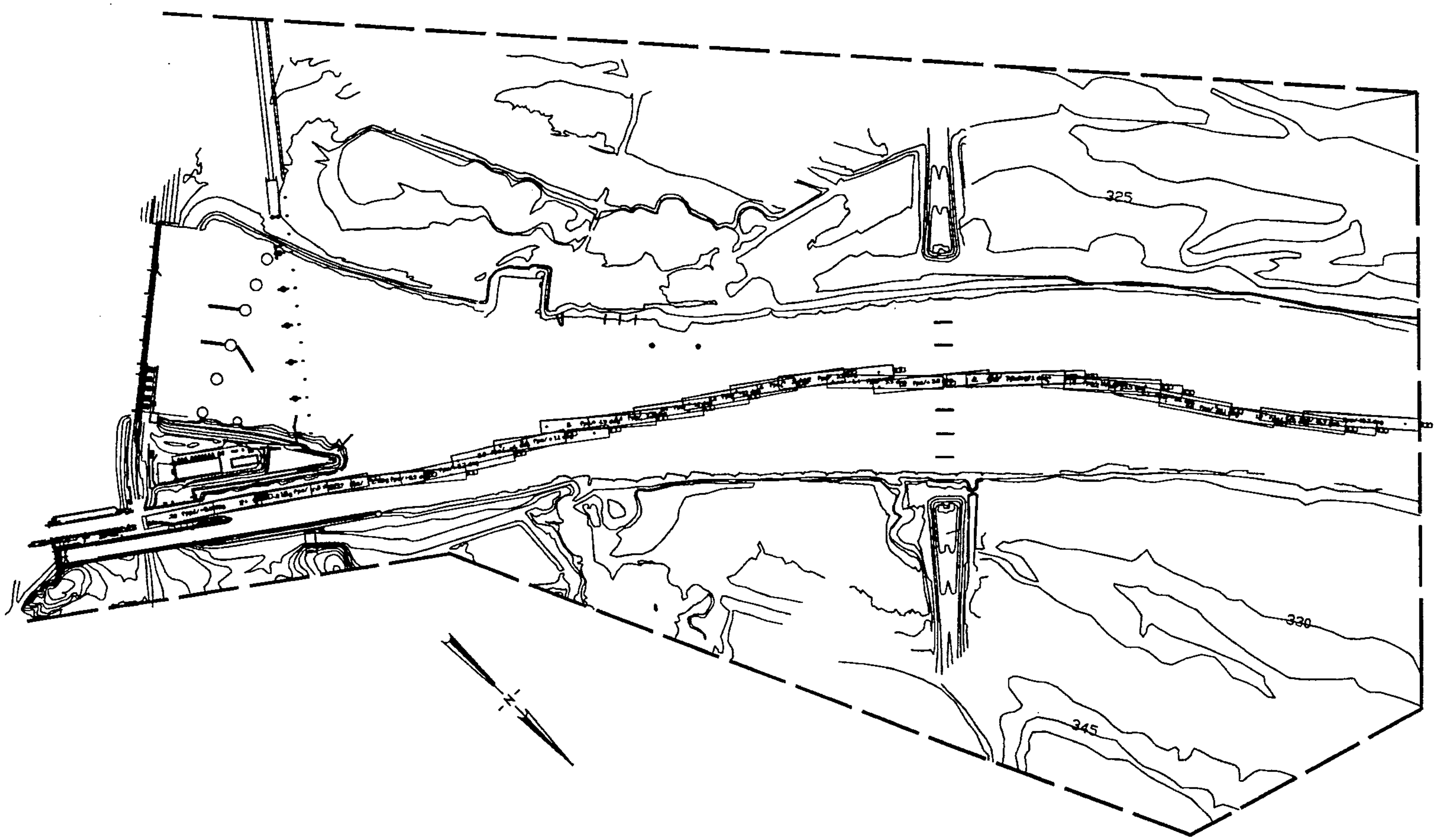
TOW TRACKS

PLAN C, UPBOUND

DISCHARGE: 35,000 CFS

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 300.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

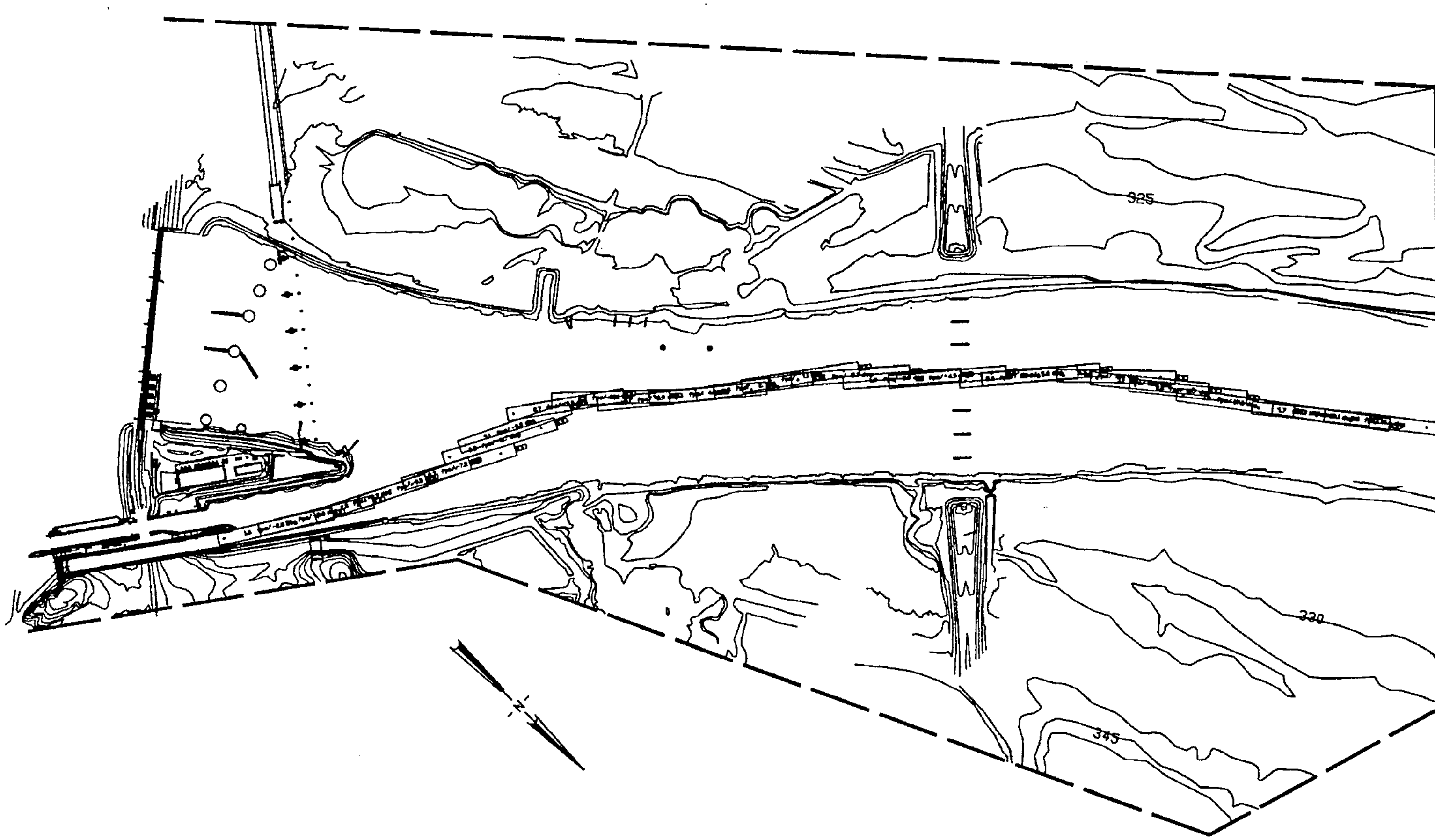
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, UPBOUND, OLD LOCK

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15-BARGE TOW

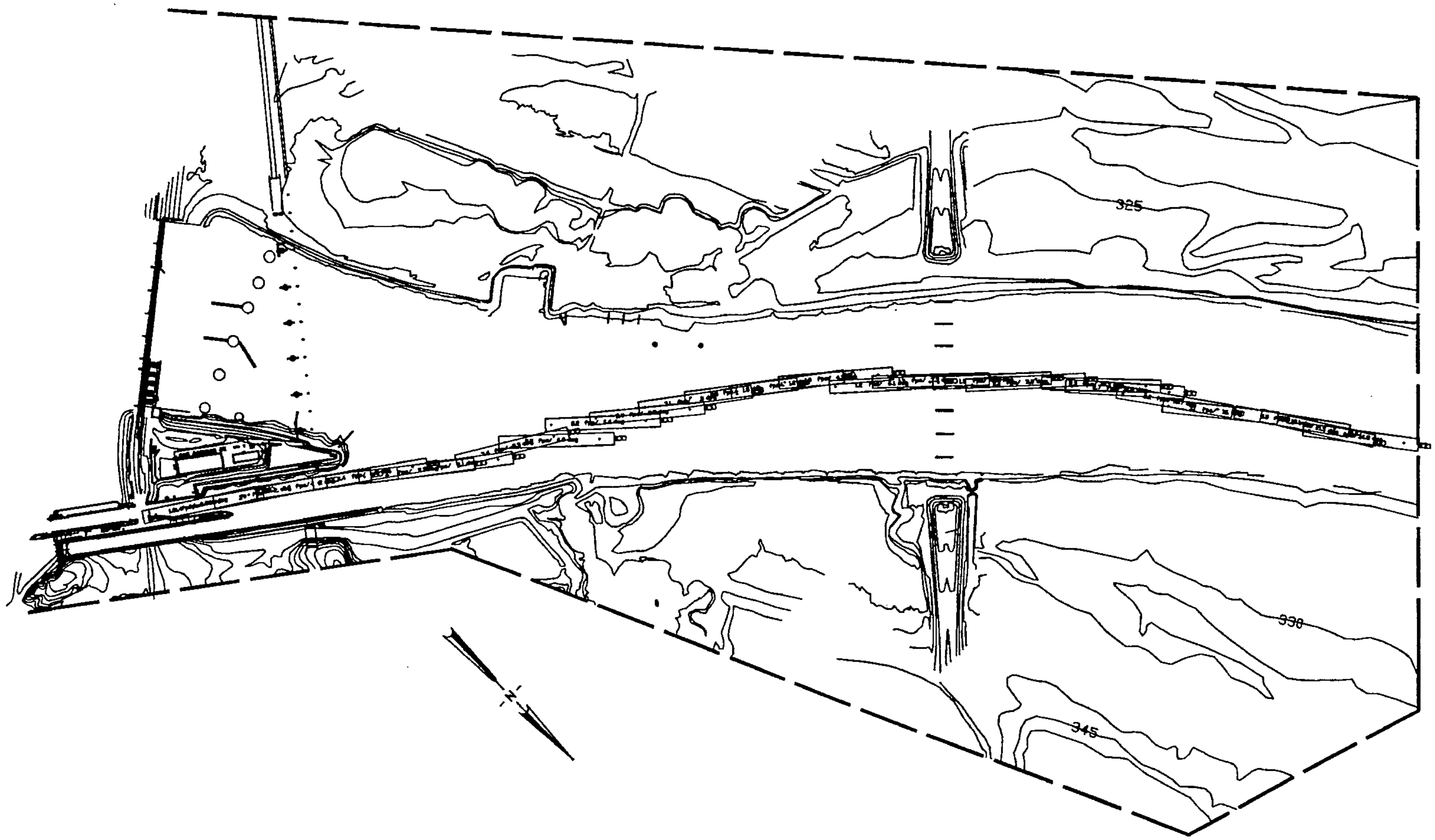
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE	0	500	1000	1500	2000
MODEL	0	5	10	15	20

TOW TRACKS
PLAN C, UPBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

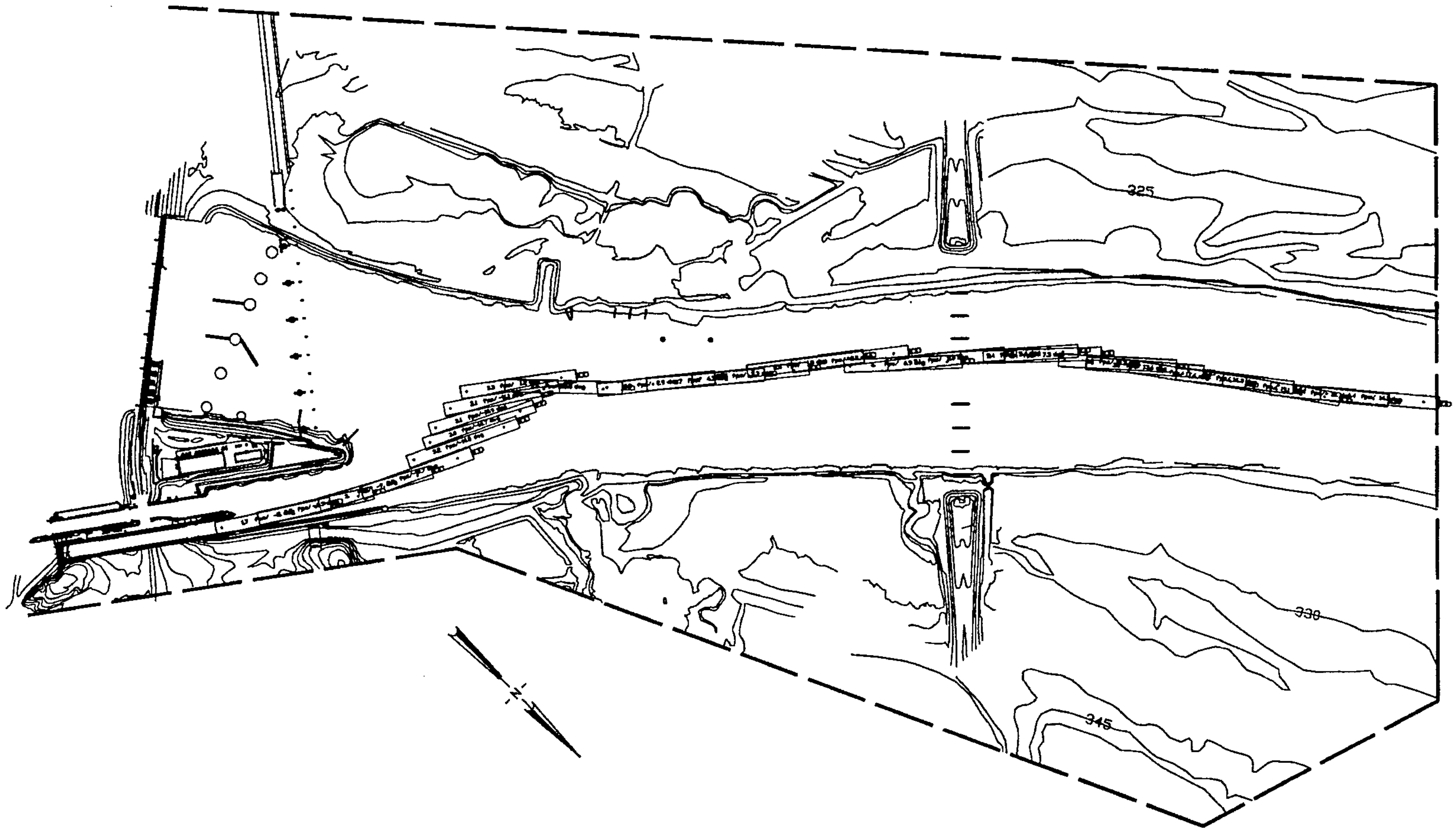
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN C, UPBOUND, OLD LOCK

DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

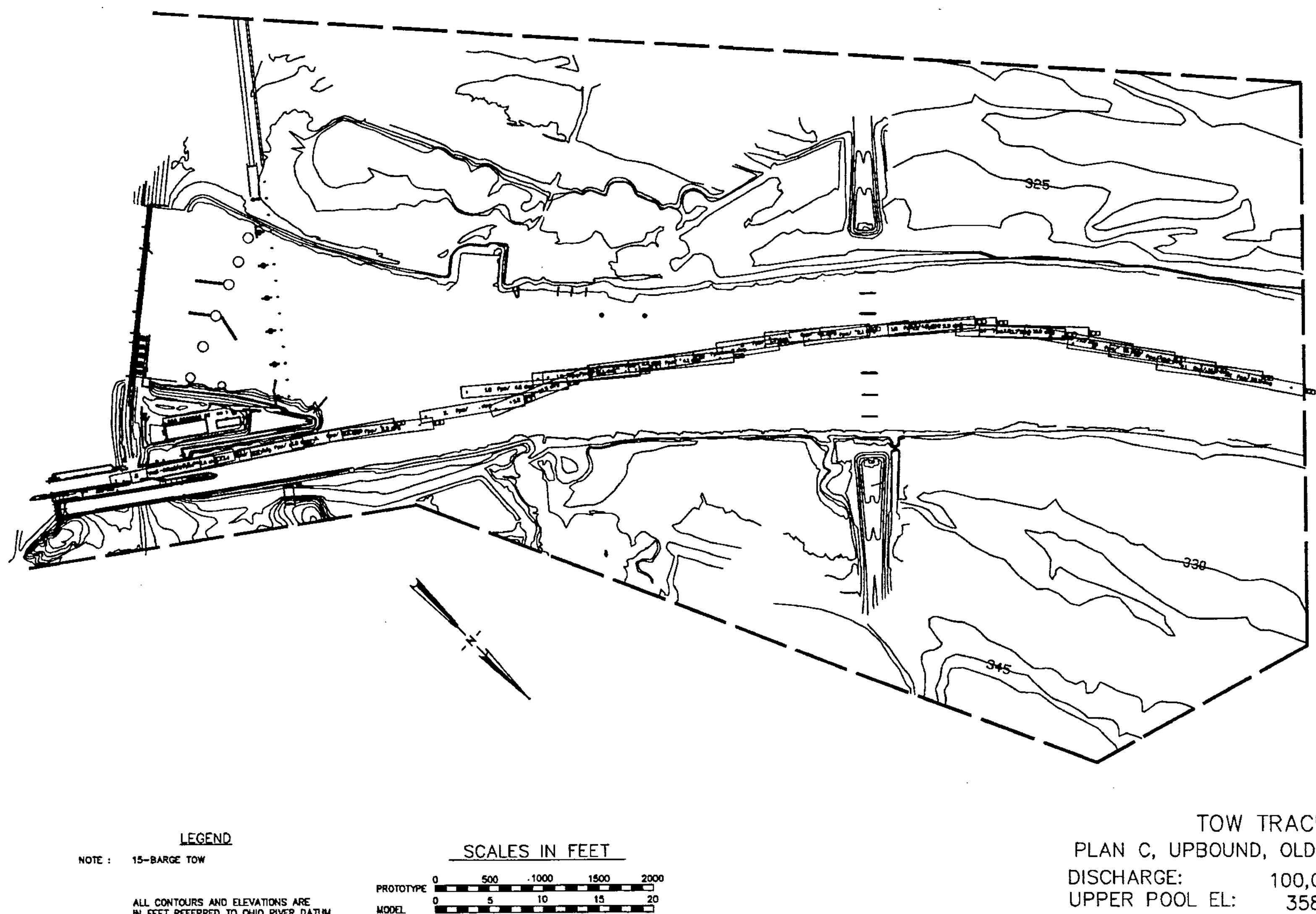
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

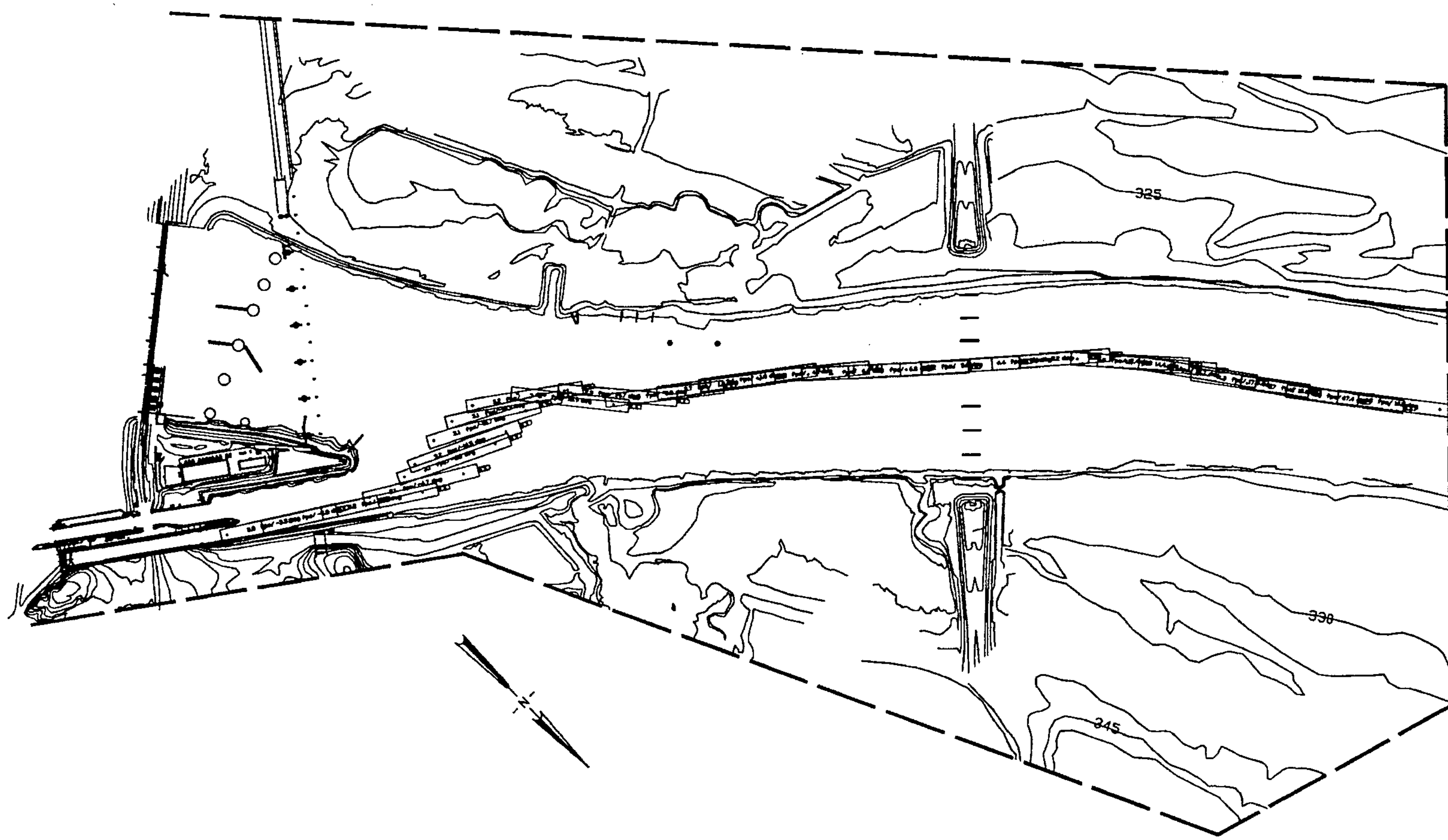
PLAN C, UPBOUND

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



TOW TRACKS
PLAN C, UPBOUND, OLD LOCK

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15–BARGE TOW

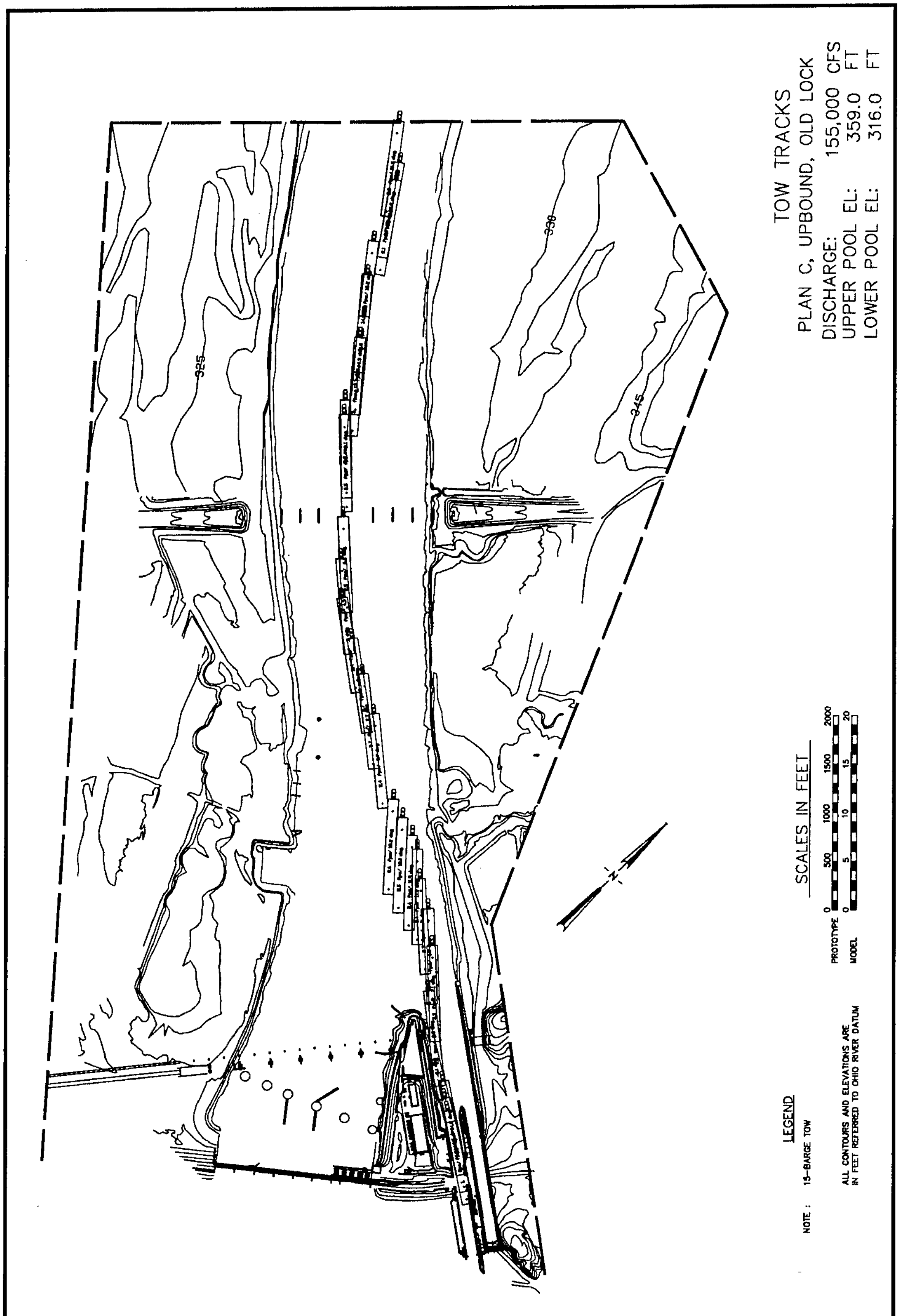
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

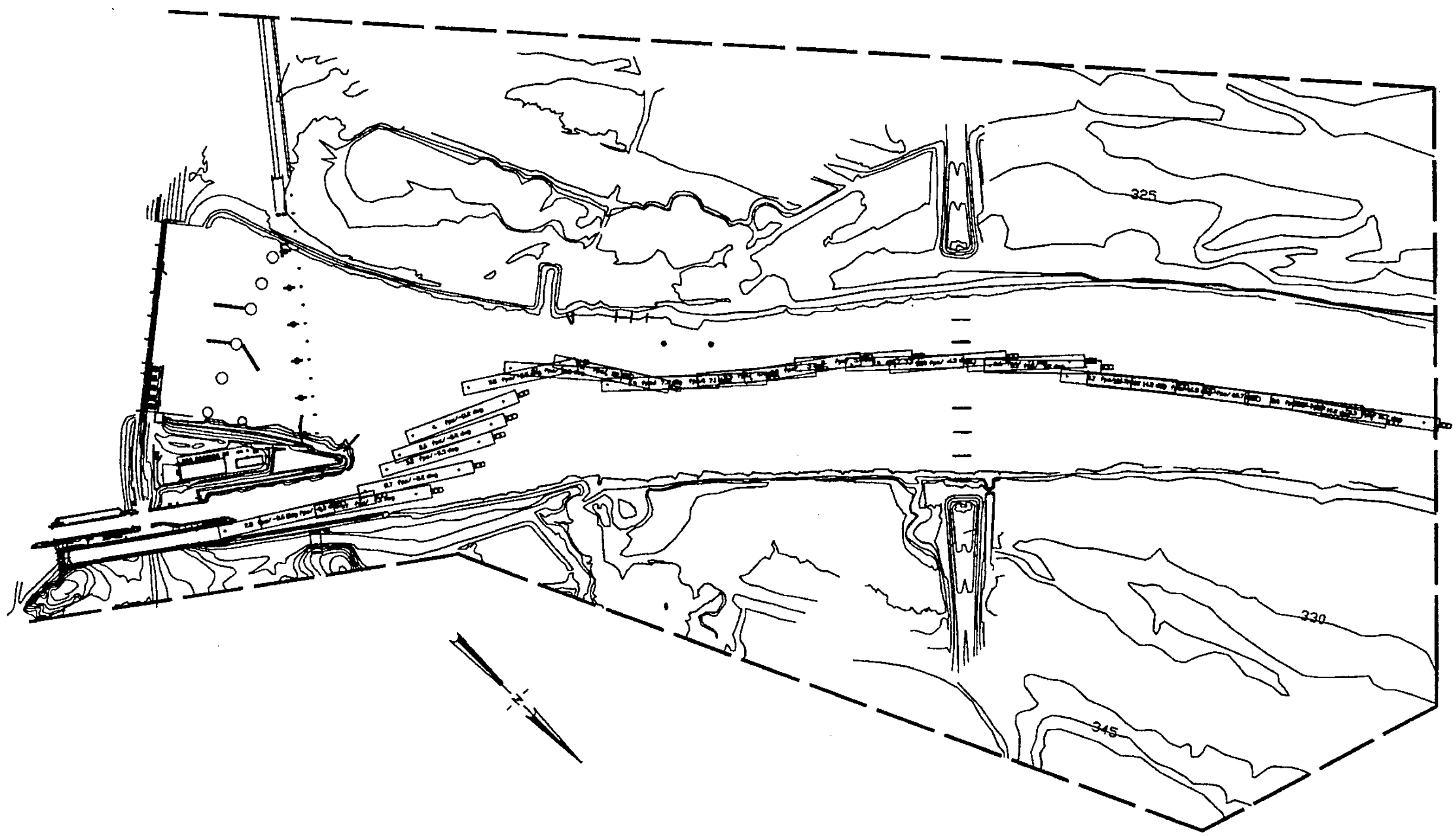
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN C, UPBOUND

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT


TOW TRACKS
PLAN C, UPBOUND, OLD LOCK
DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT
325
338
345
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

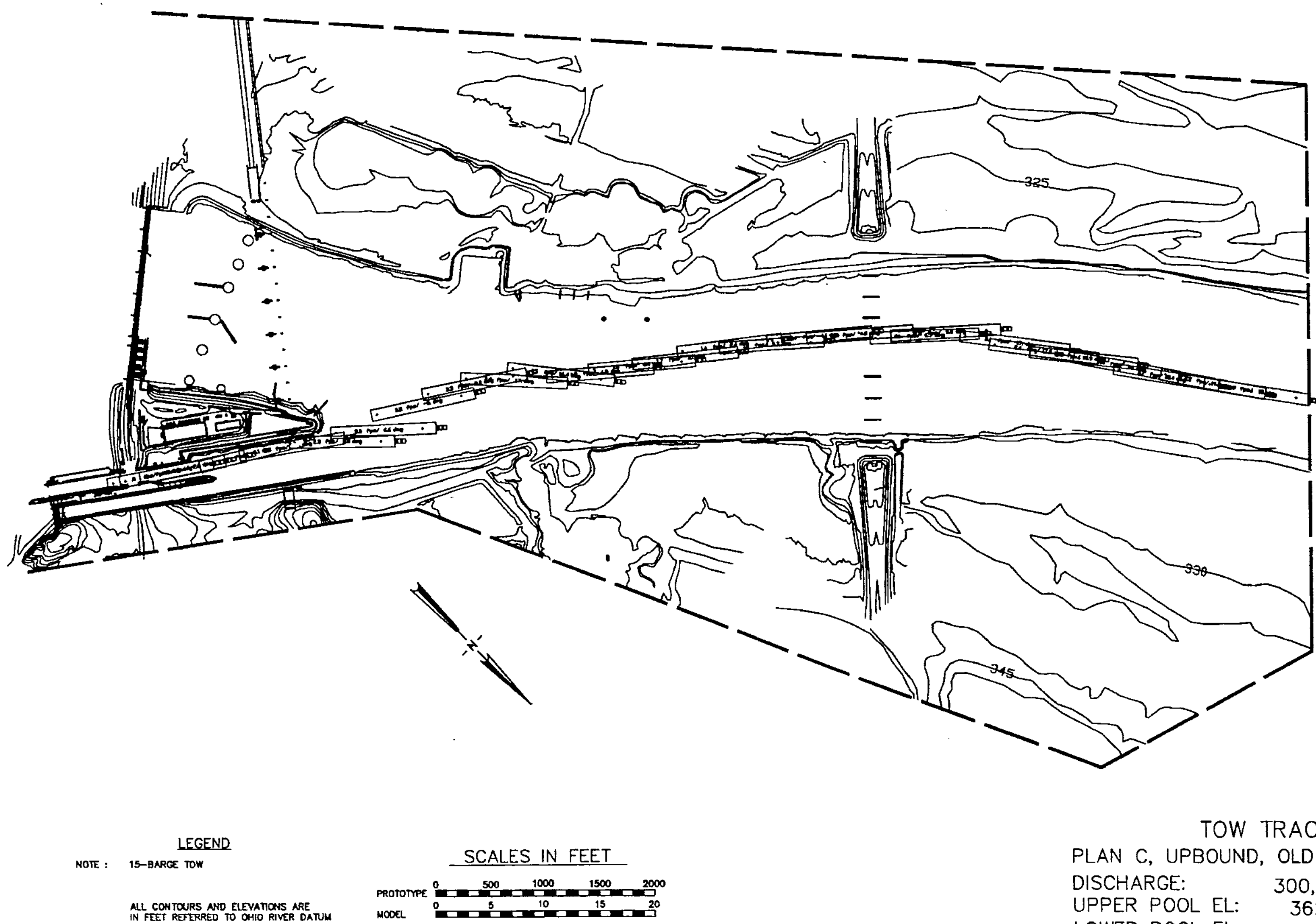
TOW TRACKS

PLAN C, UPBOUND

DISCHARGE: 300,000 CFS

UPPER POOL EL: 362.5 FT

LOWER POOL EL: 328.0 FT



LEGEND

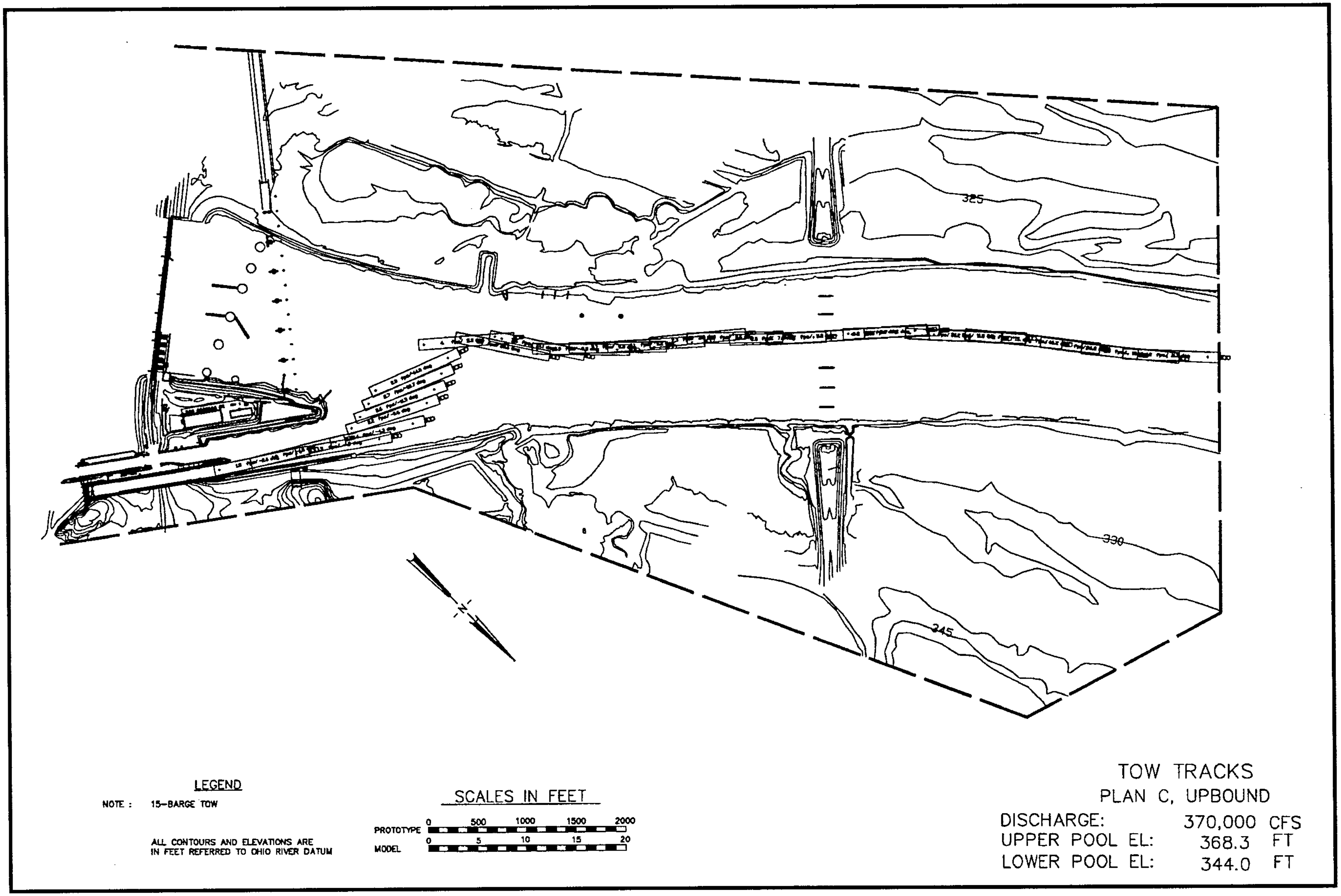
NOTE : 15–BARGE TOW

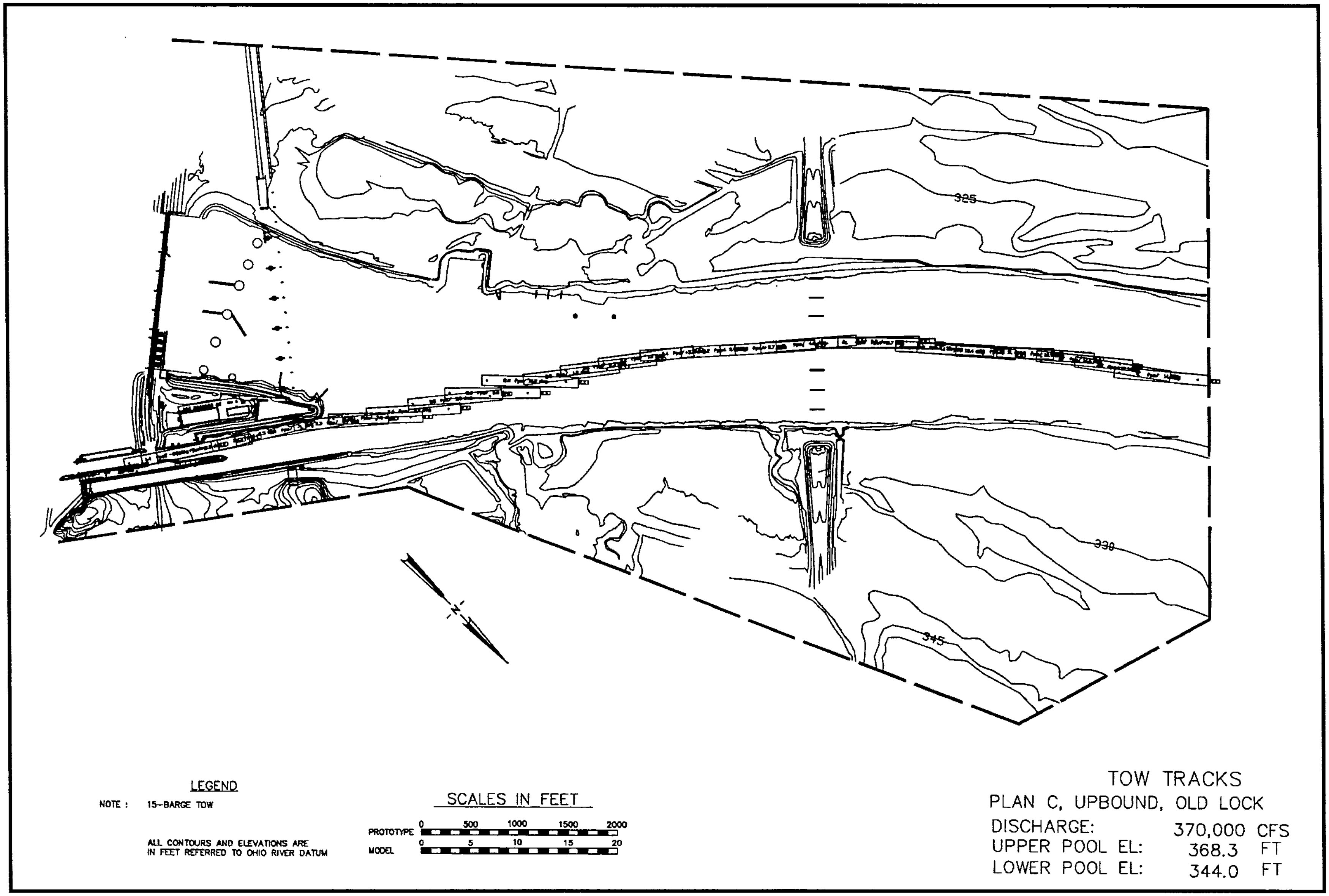
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

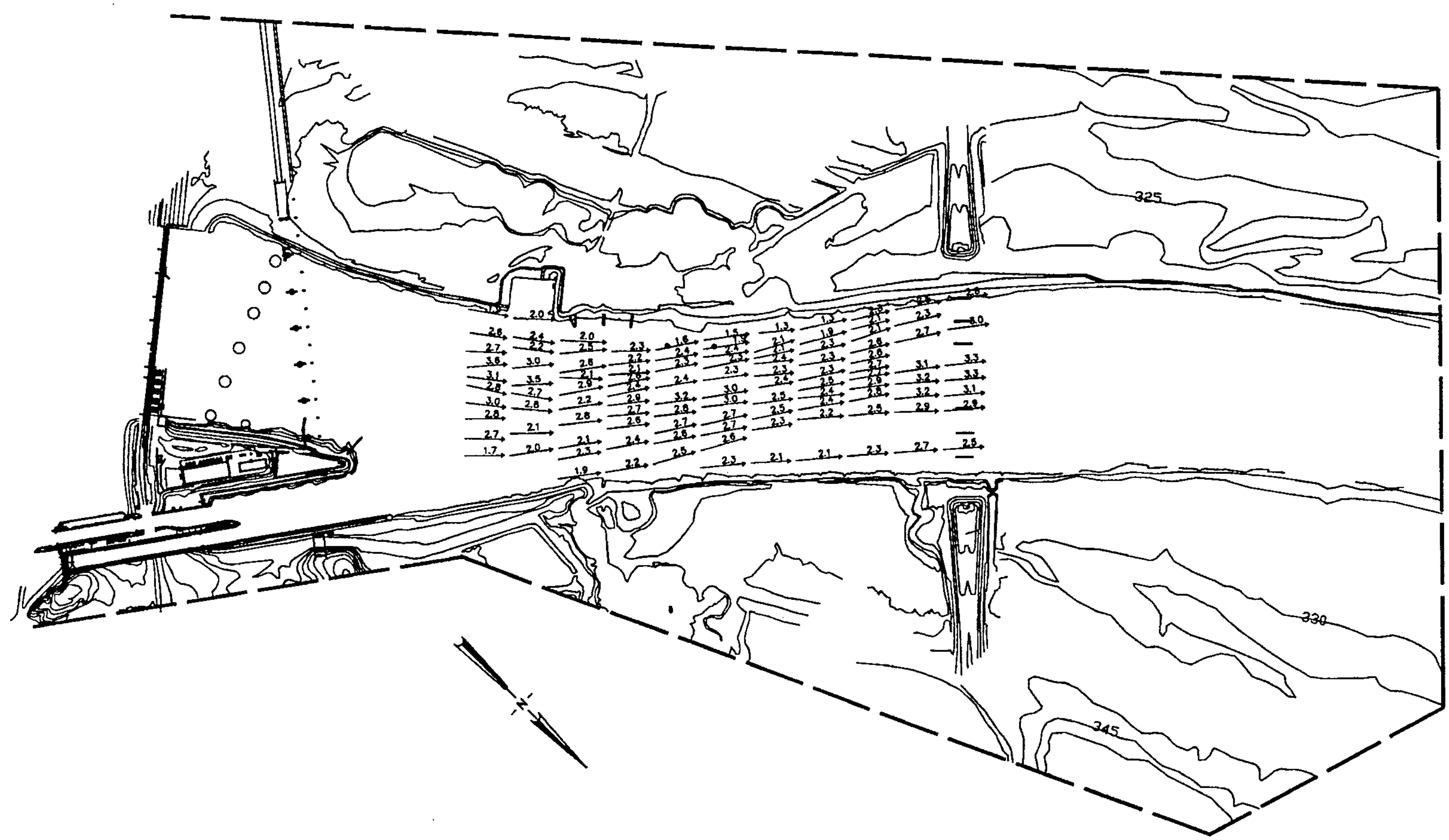
TOW TRACKS

PLAN C, UPBOUND, OLD LOCK

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT


325
330
345
N
LEGEND
NOTE : 15–BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN C, UPBOUND
DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN C, UPBOUND, OLD LOCK
DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.3 FT
LOWER POOL EL: 344.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

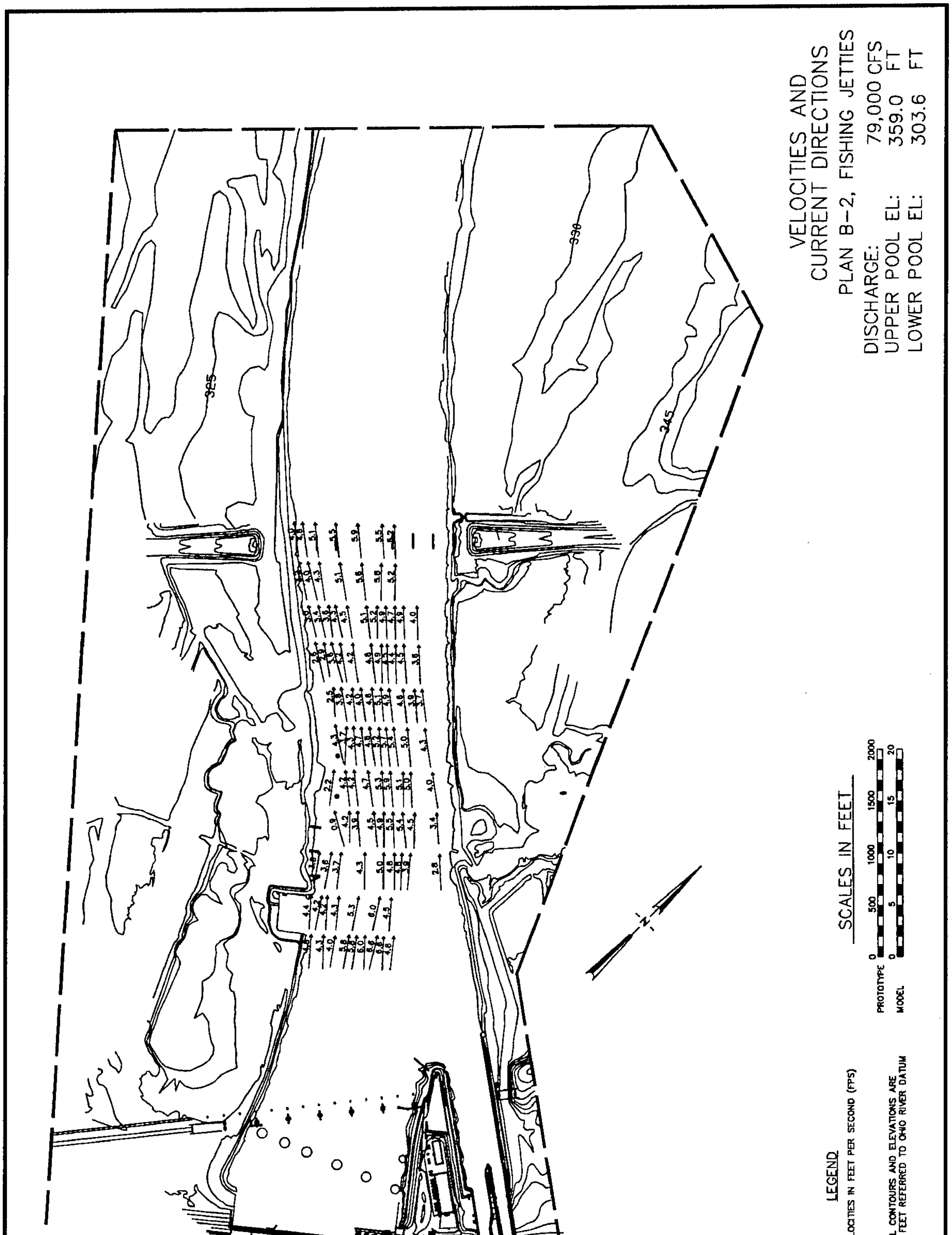
PROTOTYPE 0 500 1000 1500 2000

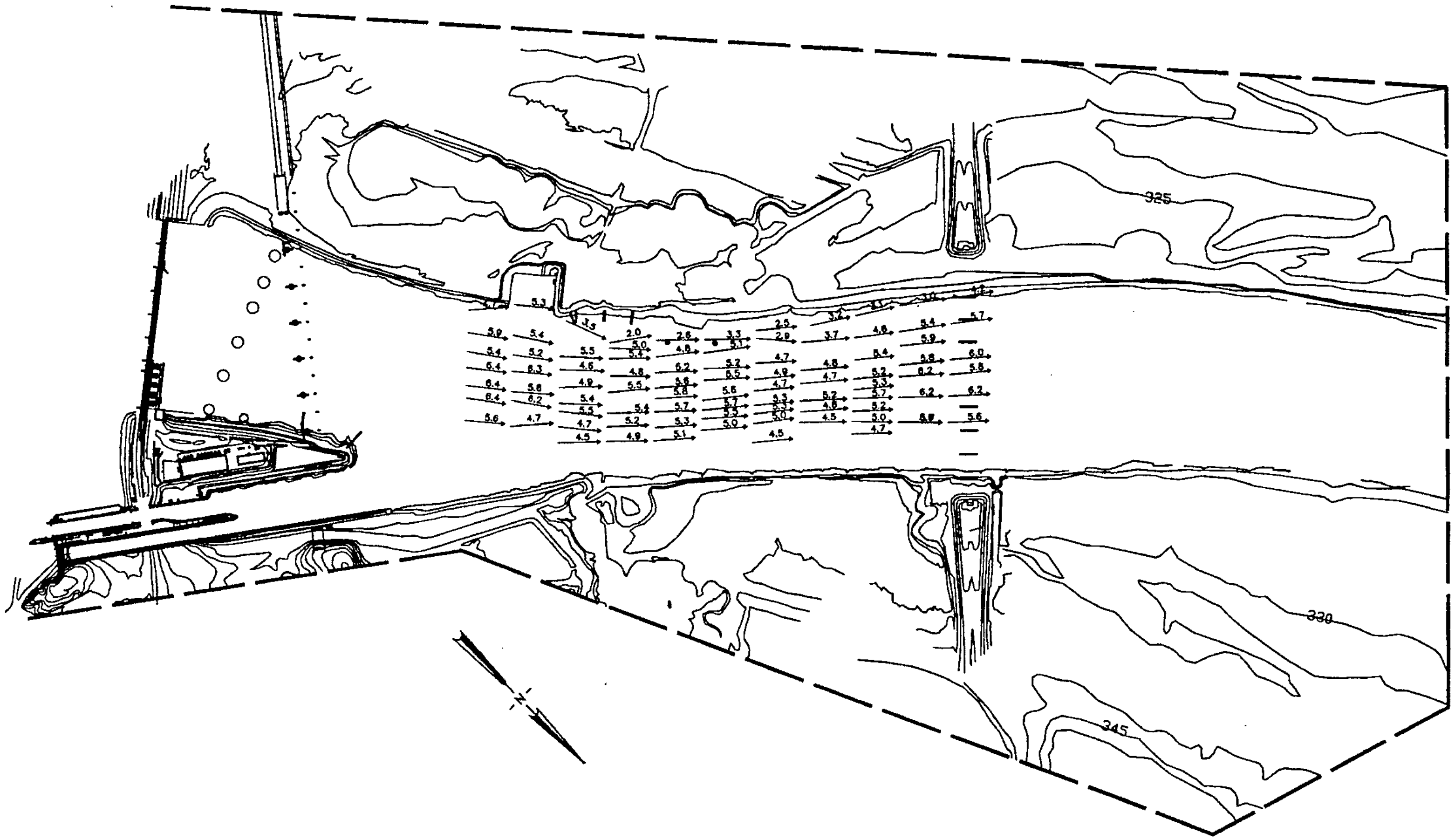
MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B–2, FISHING JETTIES

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT


VELOCITIES AND
CURRENT DIRECTIONS
PLAN B-2, FISHING JETTIES
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
N
325
330
345



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

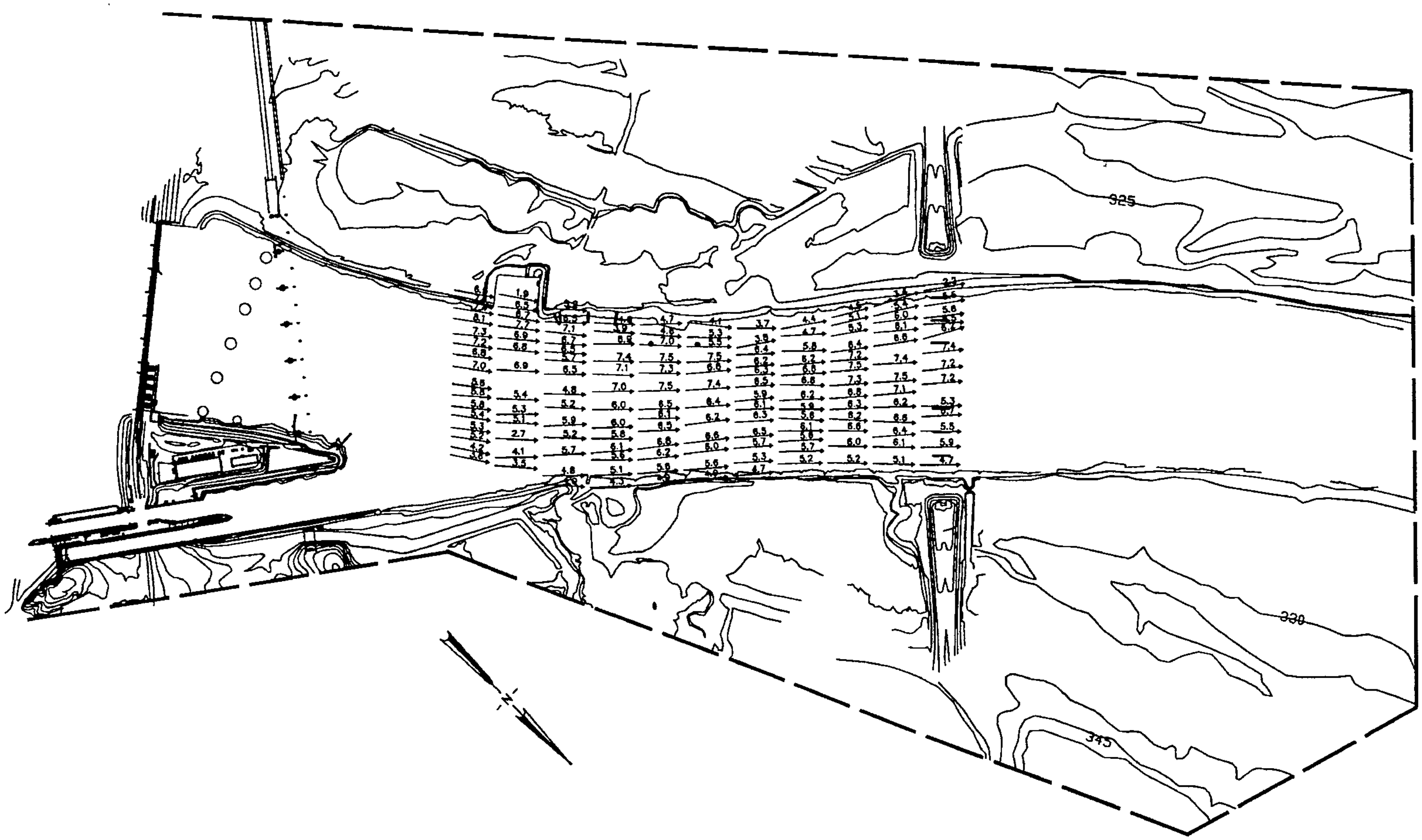
VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2, FISHING JETTIES

DISCHARGE: 100,000 CFS

UPPER POOL EL: 358.0 FT

LOWER POOL EL: 306.3 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM.

SCALES IN FEET

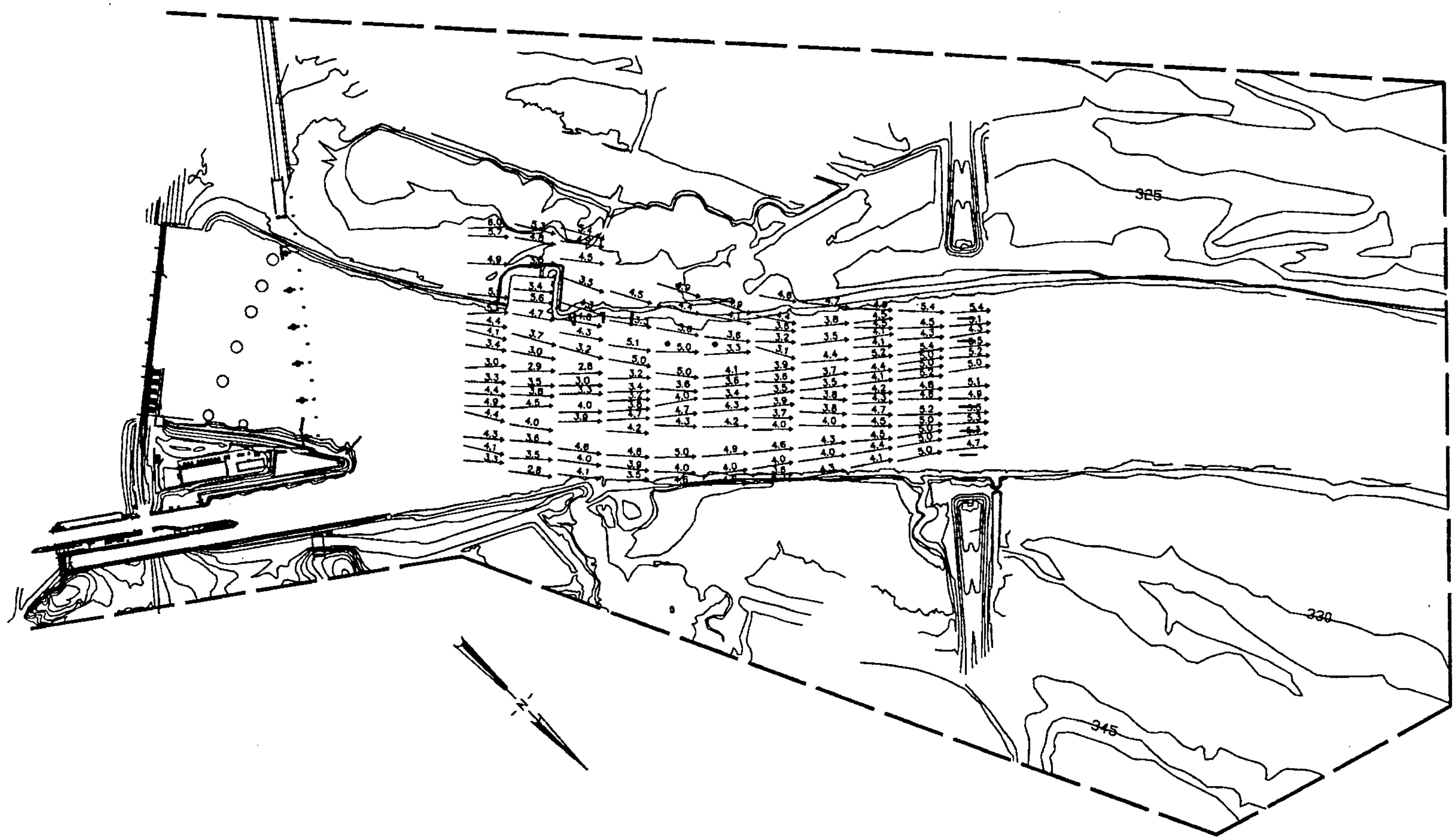
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2, FISHING JETTIES

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

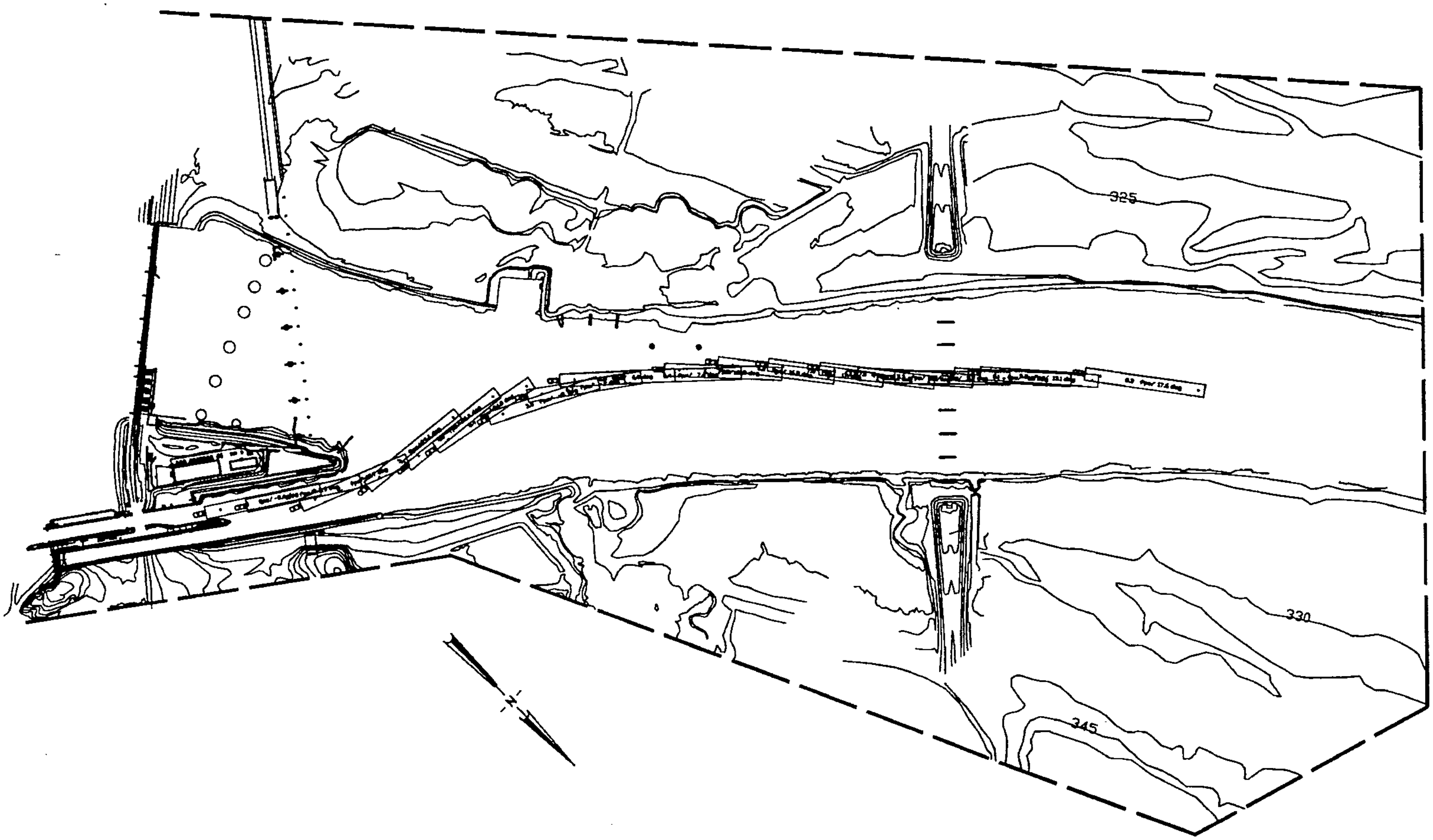
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B–2, FISHING JETTIES

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT



LEGEND

NOTE : 15-BARGE TOW

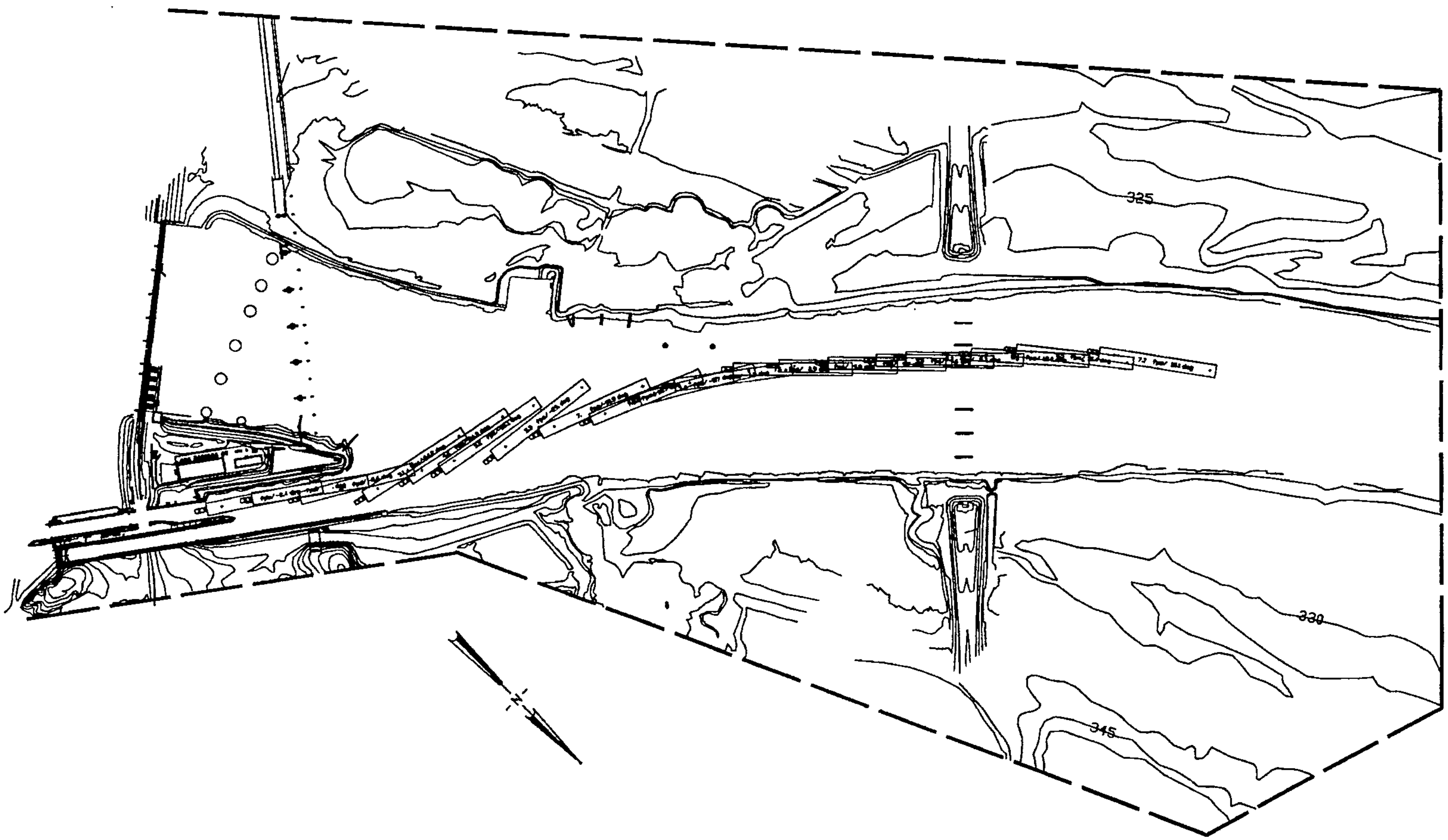
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B–2, FISHING JETTIES, DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

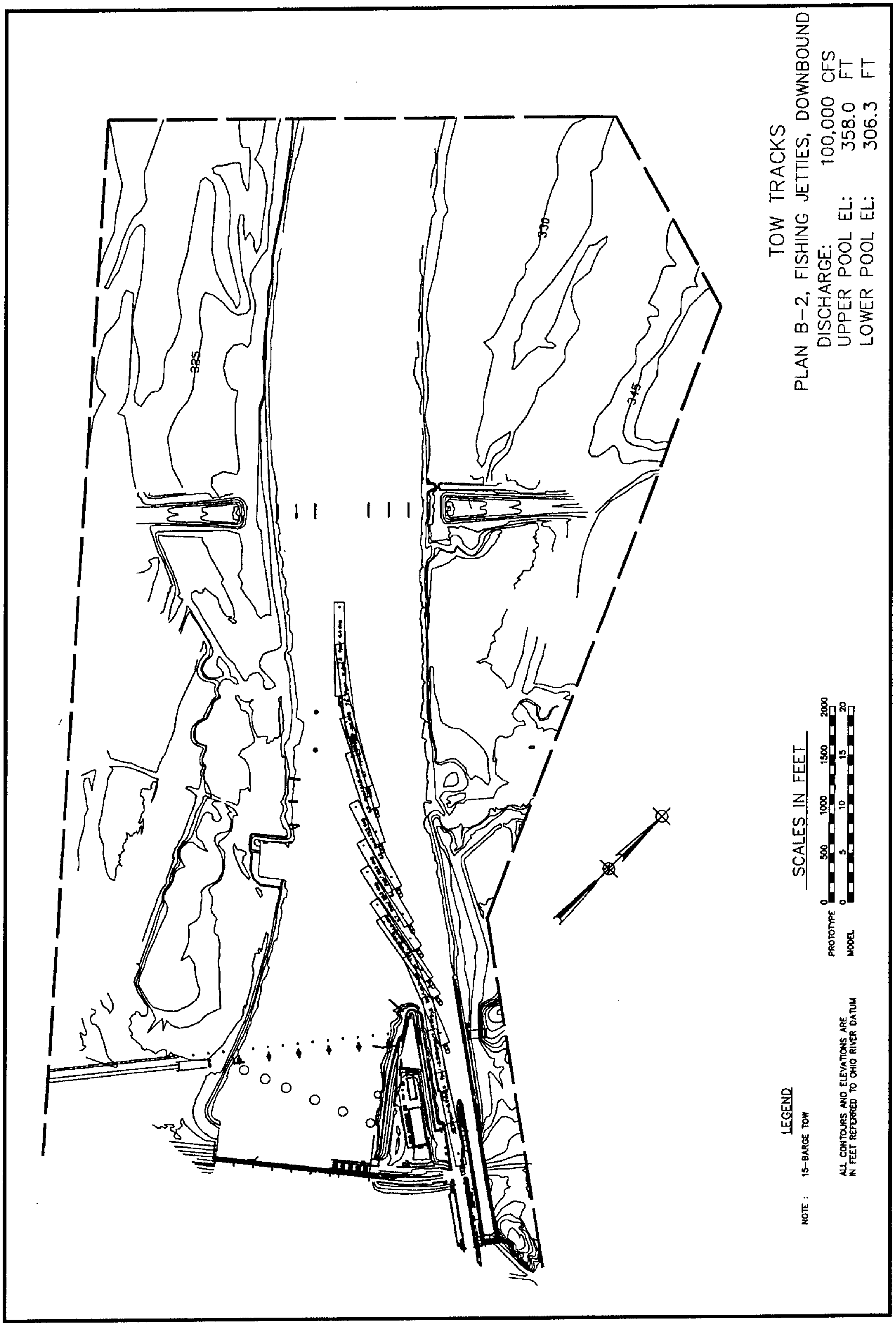
PROTOTYPE 0 500 1000 1500 2000

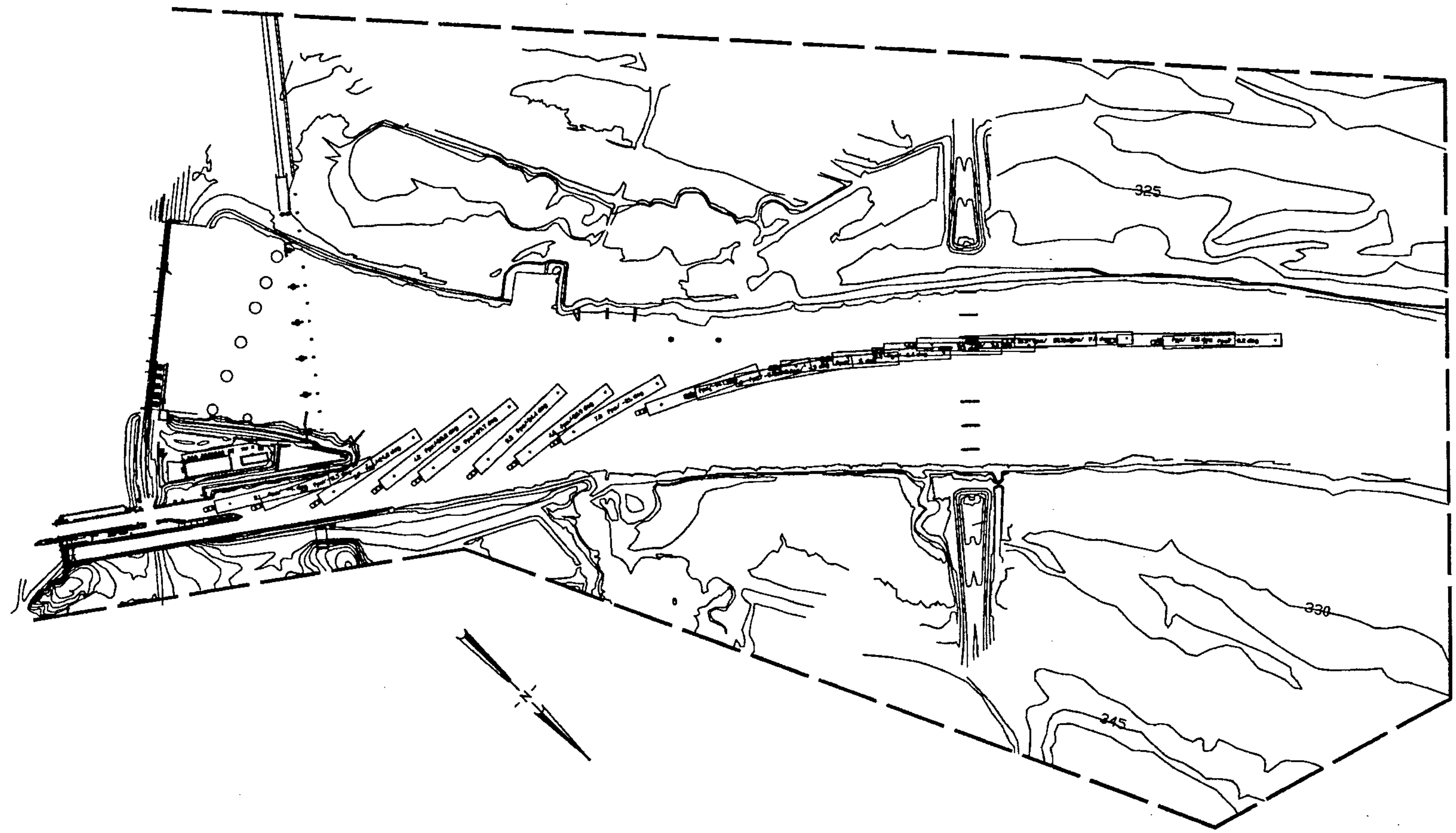
MODEL 0 5 10 15 20

TOW TRACKS

PLAN B–2, FISHING JETTIES, DOWNBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT


TOW TRACKS
PLAN B-2, FISHING JETTIES, DOWNBOUND
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT
335
330
345
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

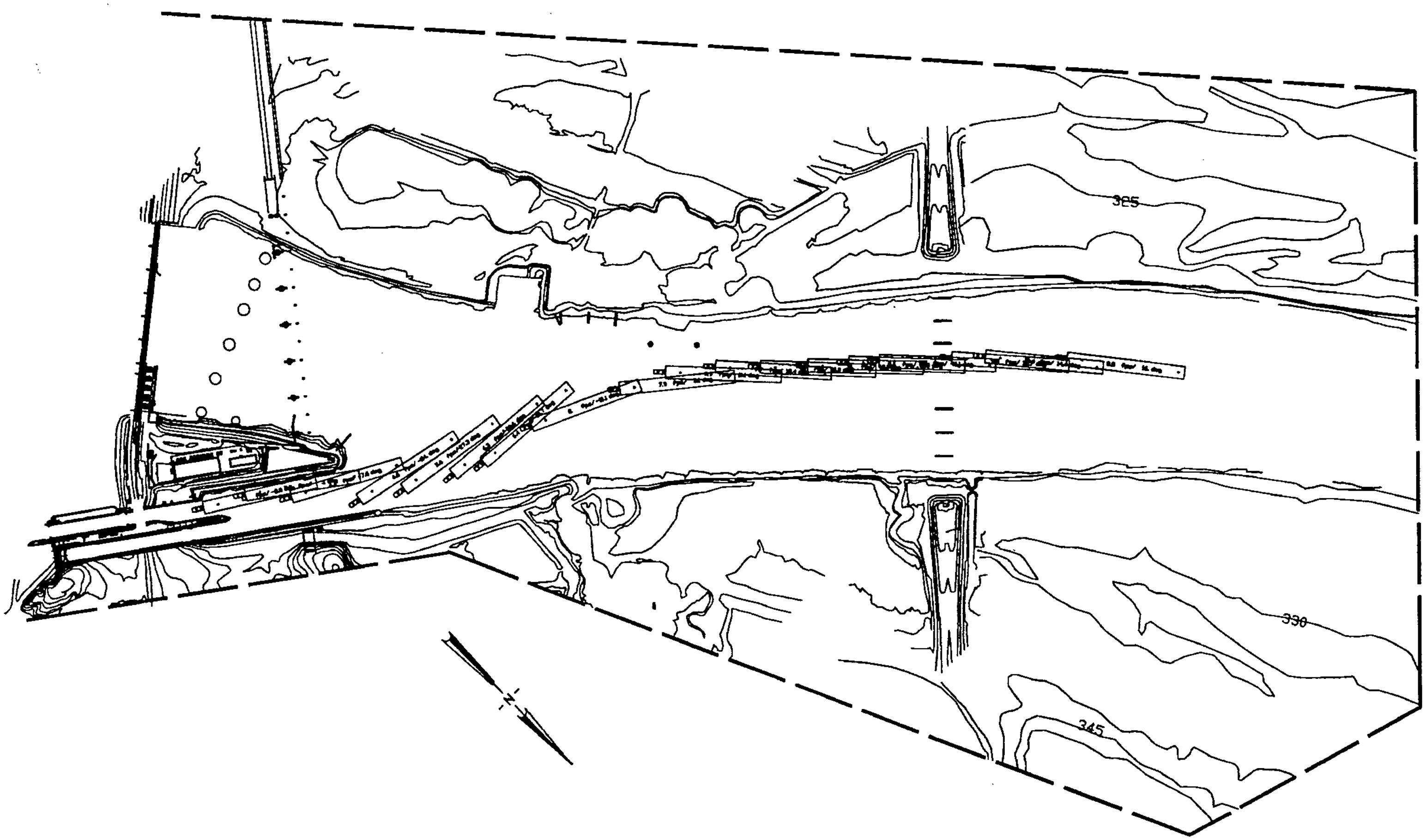
TOW TRACKS

PLAN B-2, FISHING JETTIES, DOWNBOUND

DISCHARGE: 300,000 CFS

UPPER POOL EL: 362.3 FT

LOWER POOL EL: 328.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

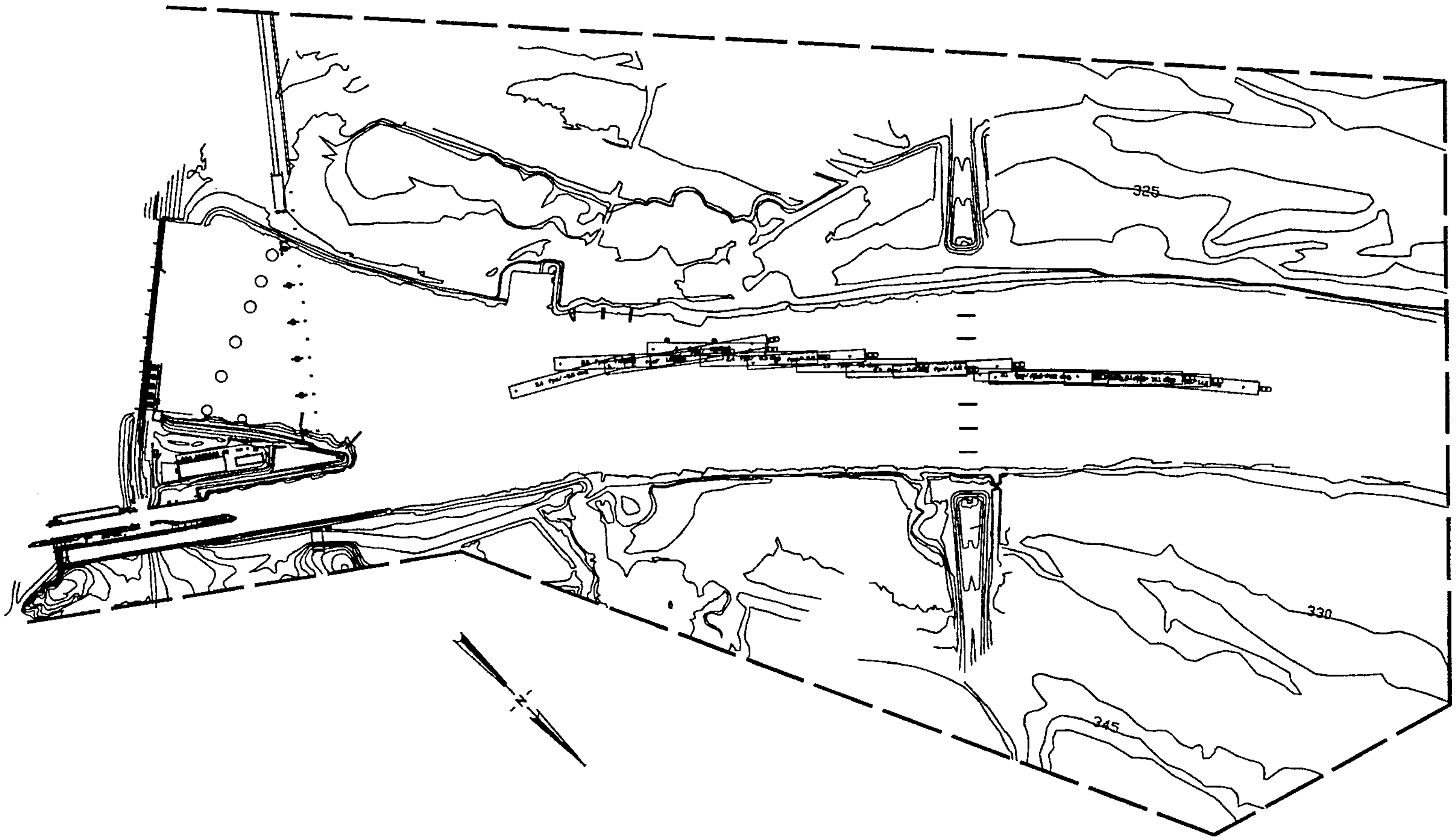
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, FISHING JETTIES, DOWNBOUND

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.5 FT
LOWER POOL EL:	344.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

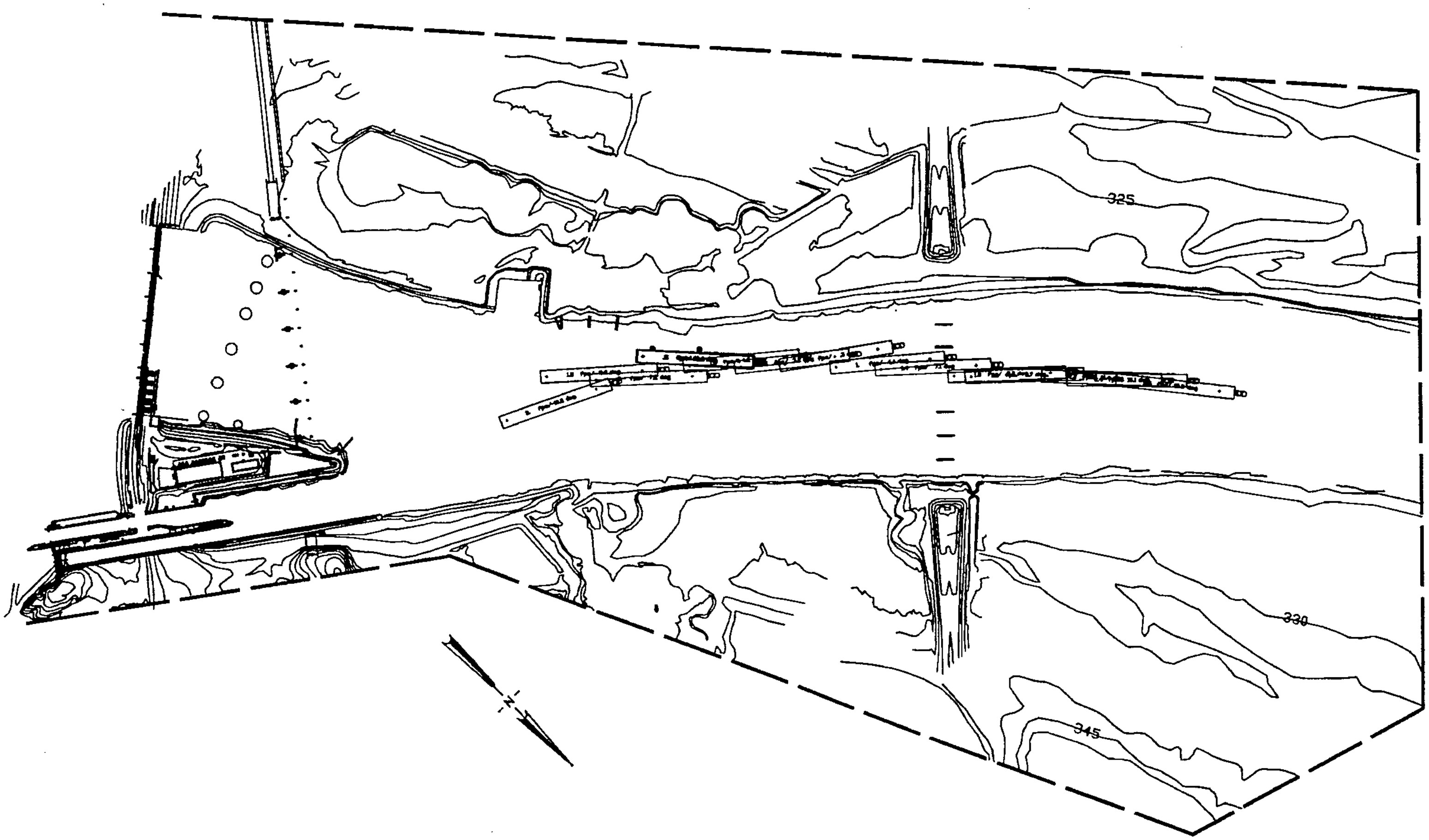
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, FISHING JETTIES, UPBOUND

DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT



TOW TRACKS
PLAN B-2, FISHING JETTIES, UPBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT

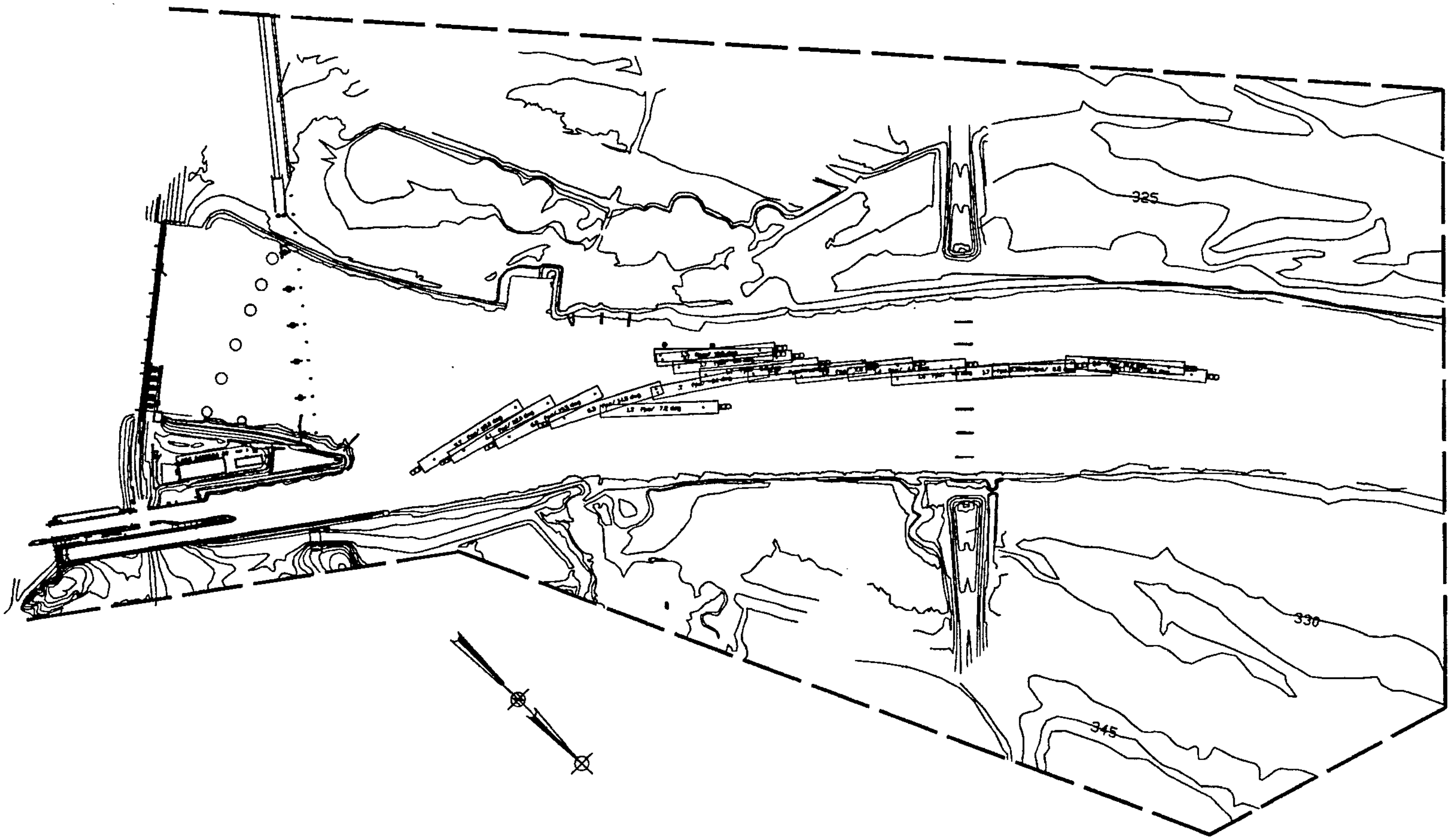
LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

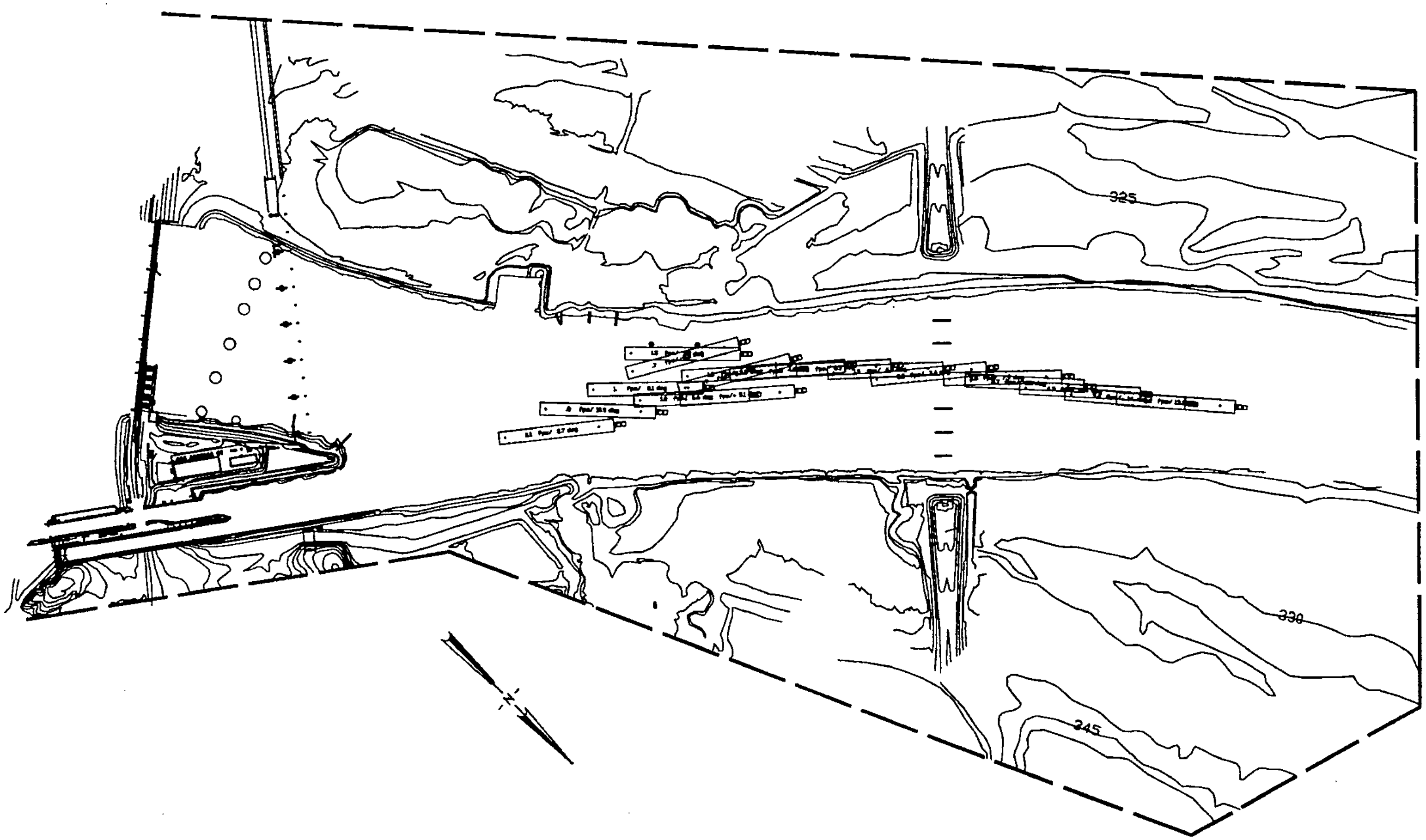
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, FISHING JETTIES, UPBOUND

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

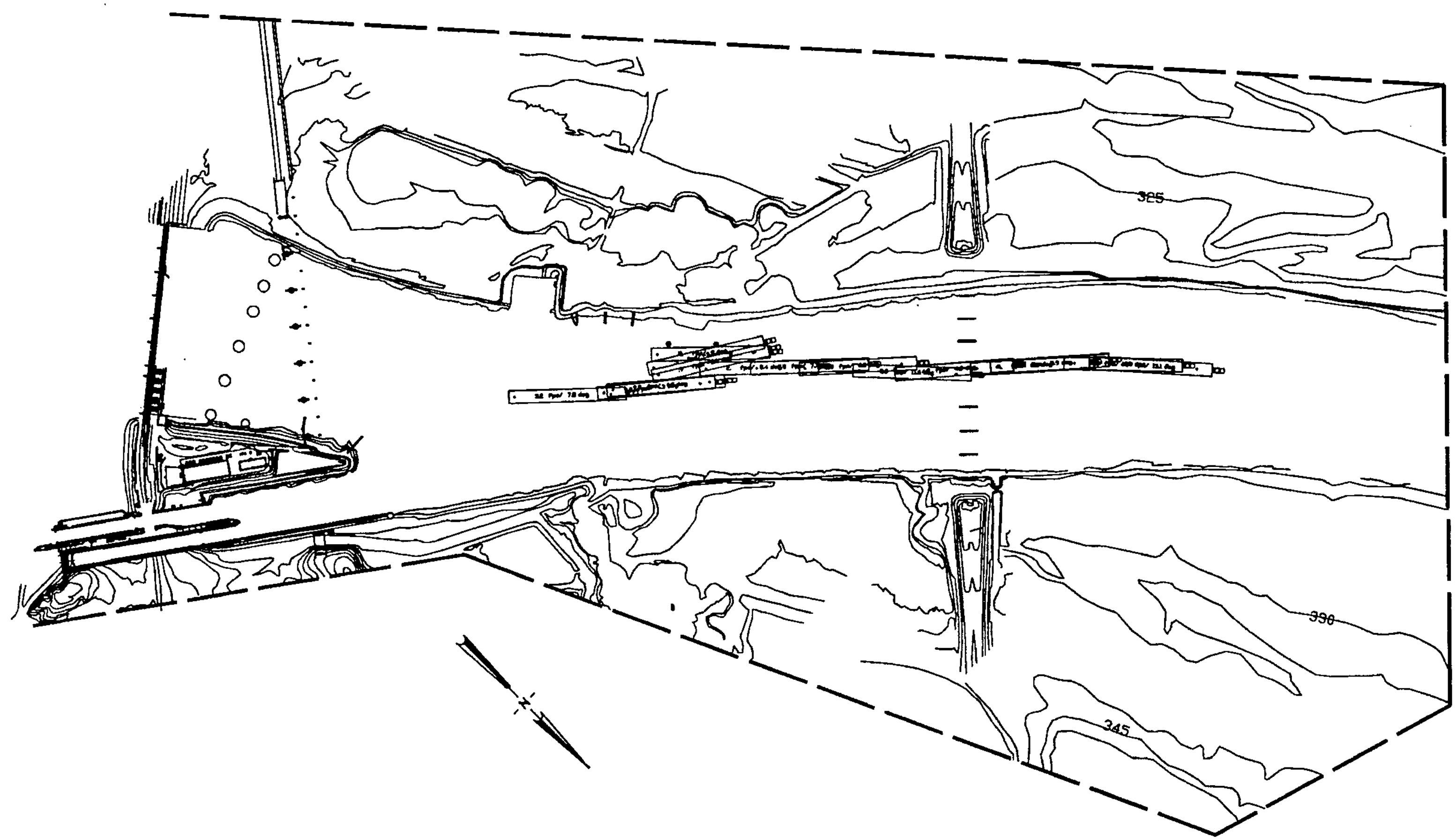
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

PLAN B-2, FISHING JETTIES, UPBOUND

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.3 FT
LOWER POOL EL:	328.0 FT



LEGEND

NOTE : 15-BARGE TOW

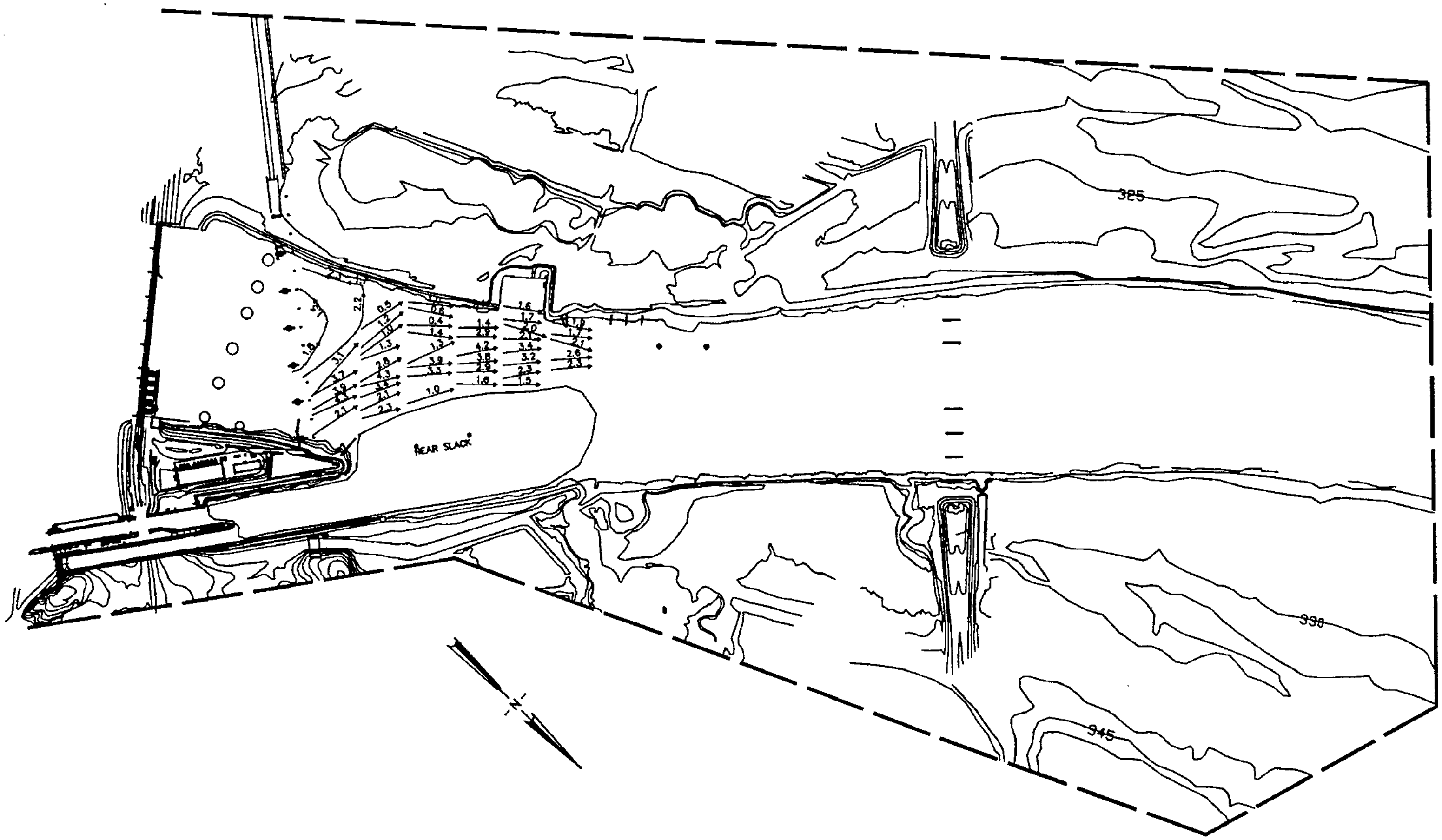
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-2, FISHING JETTIES, UPBOUND

DISCHARGE: 370,000 CFS
UPPER POOL EL: 368.5 FT
LOWER POOL EL: 344.0 FT



VELOCITIES AND
CURRENT DIRECTIONS

PLAN B–2, FLOAT–IN

DISCHARGE: 301.5 TO 303.0 TW
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.0 FT

LEGEND

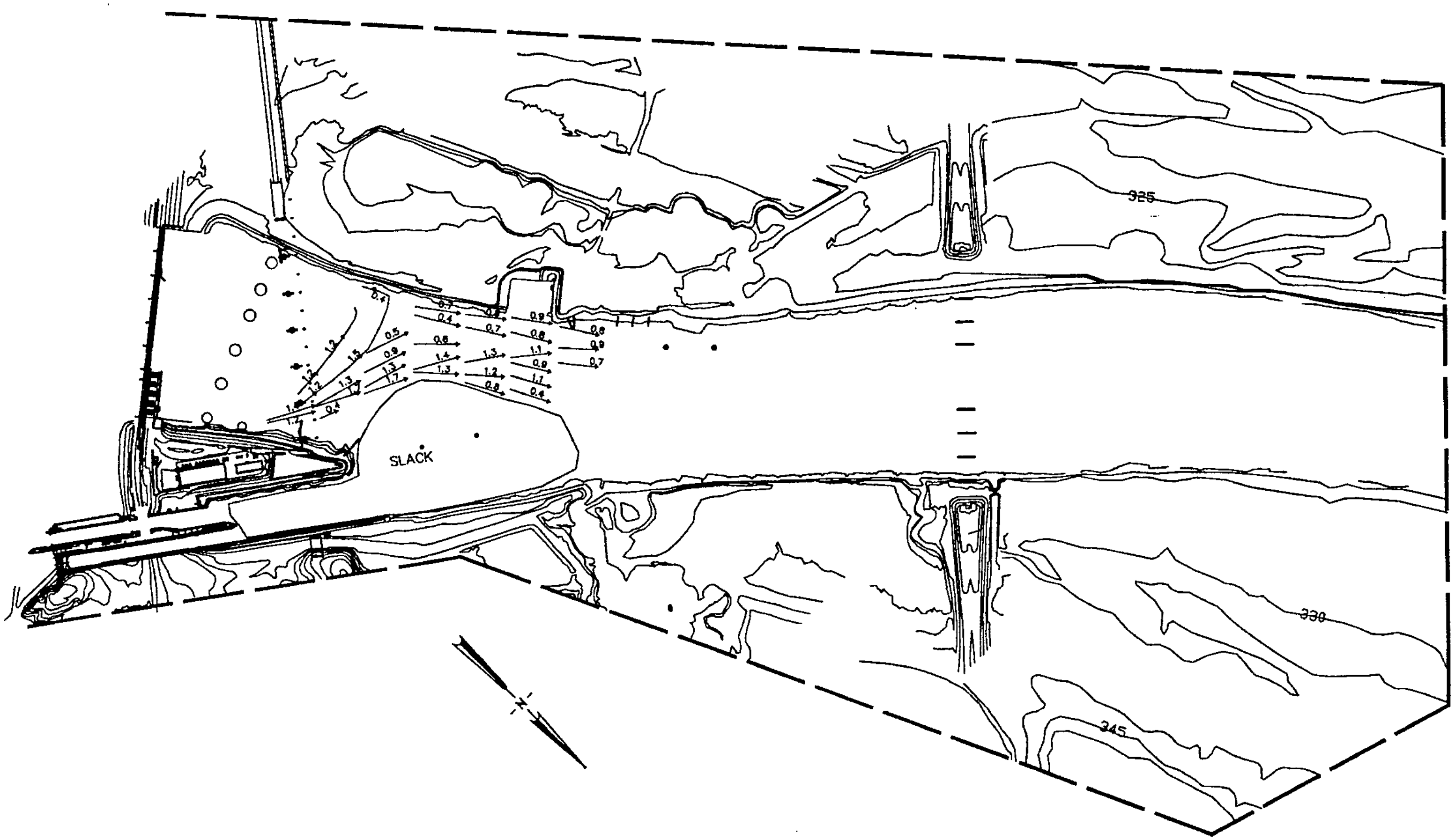
2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

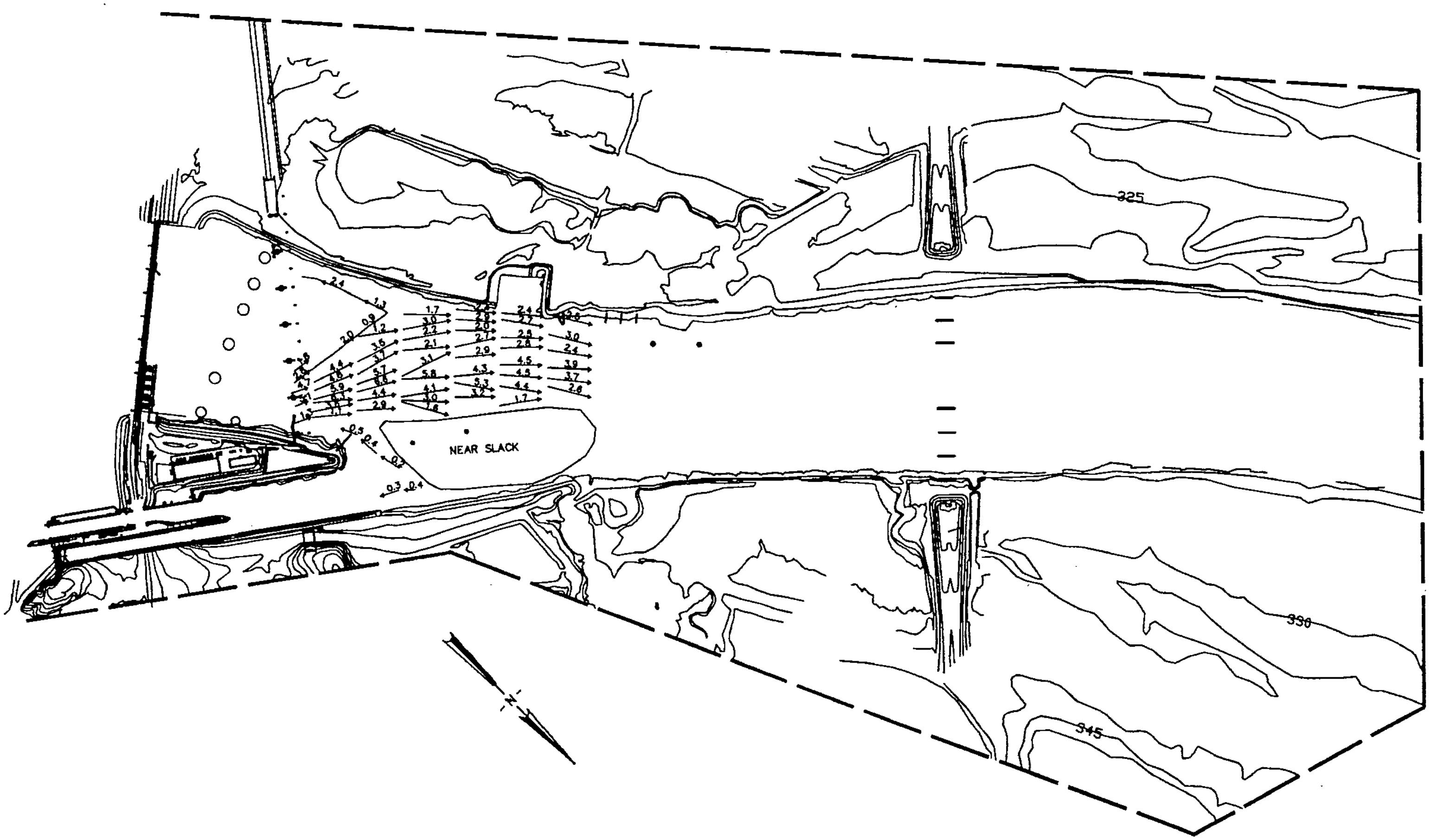
VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2, FLOAT-IN

DISCHARGE: 303.0 TW, NO FLOW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT



LEGEND

← 2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

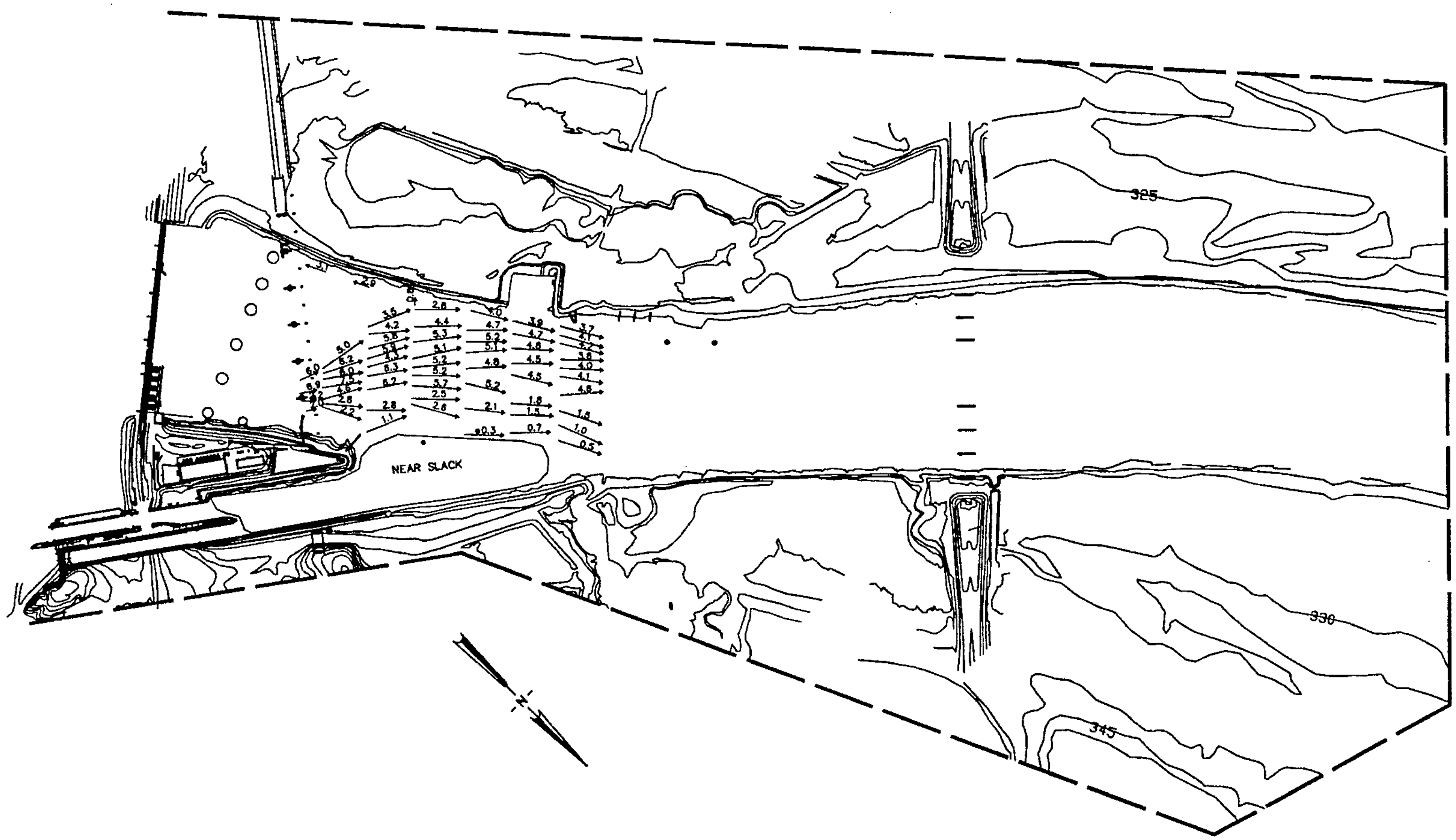
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2, FLOAT-IN

DISCHARGE: 300.0 TO 303.0 TW
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

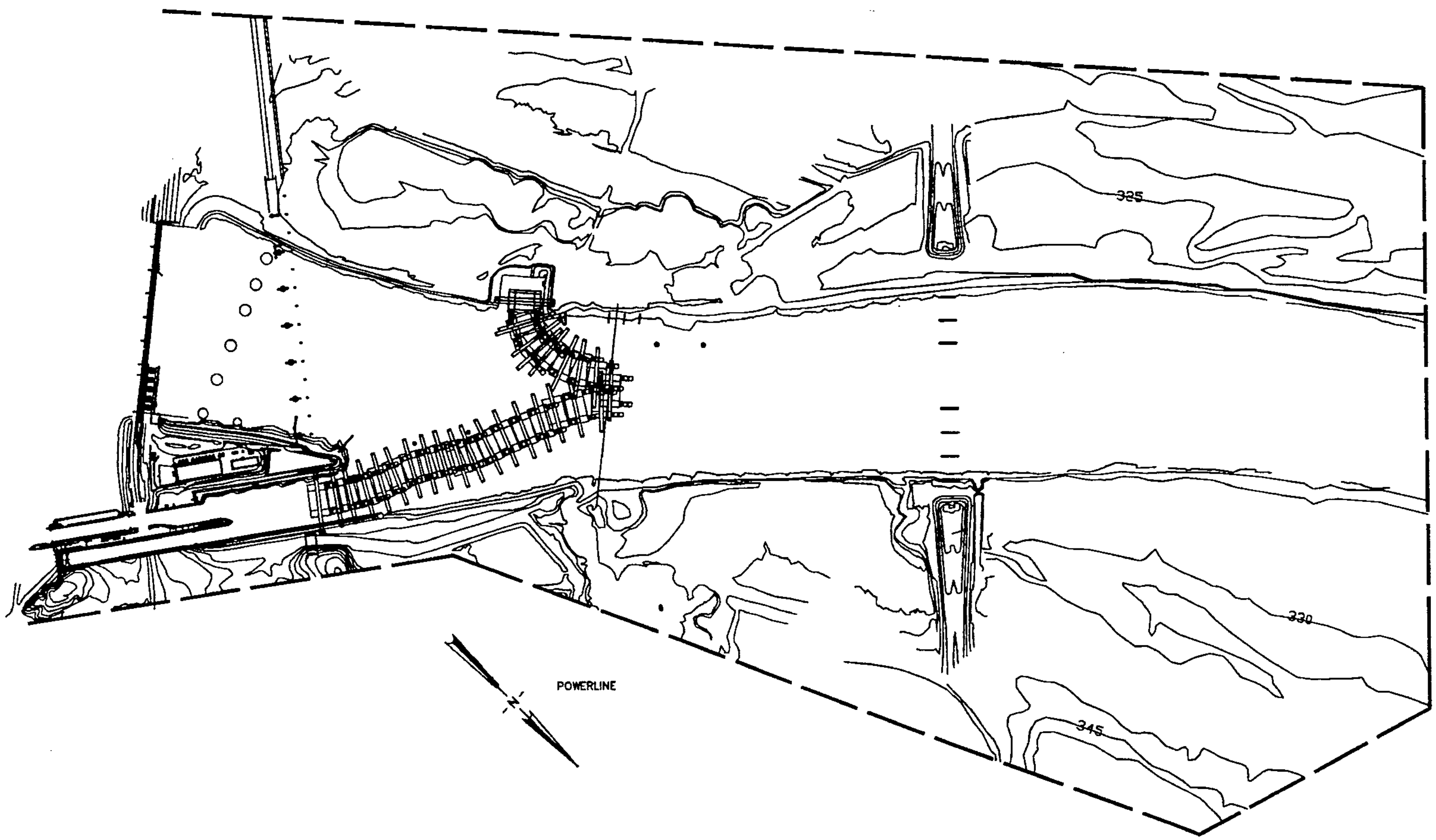
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B–2, FLOAT–IN

DISCHARGE: 306.0 TO 303.0 TW
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

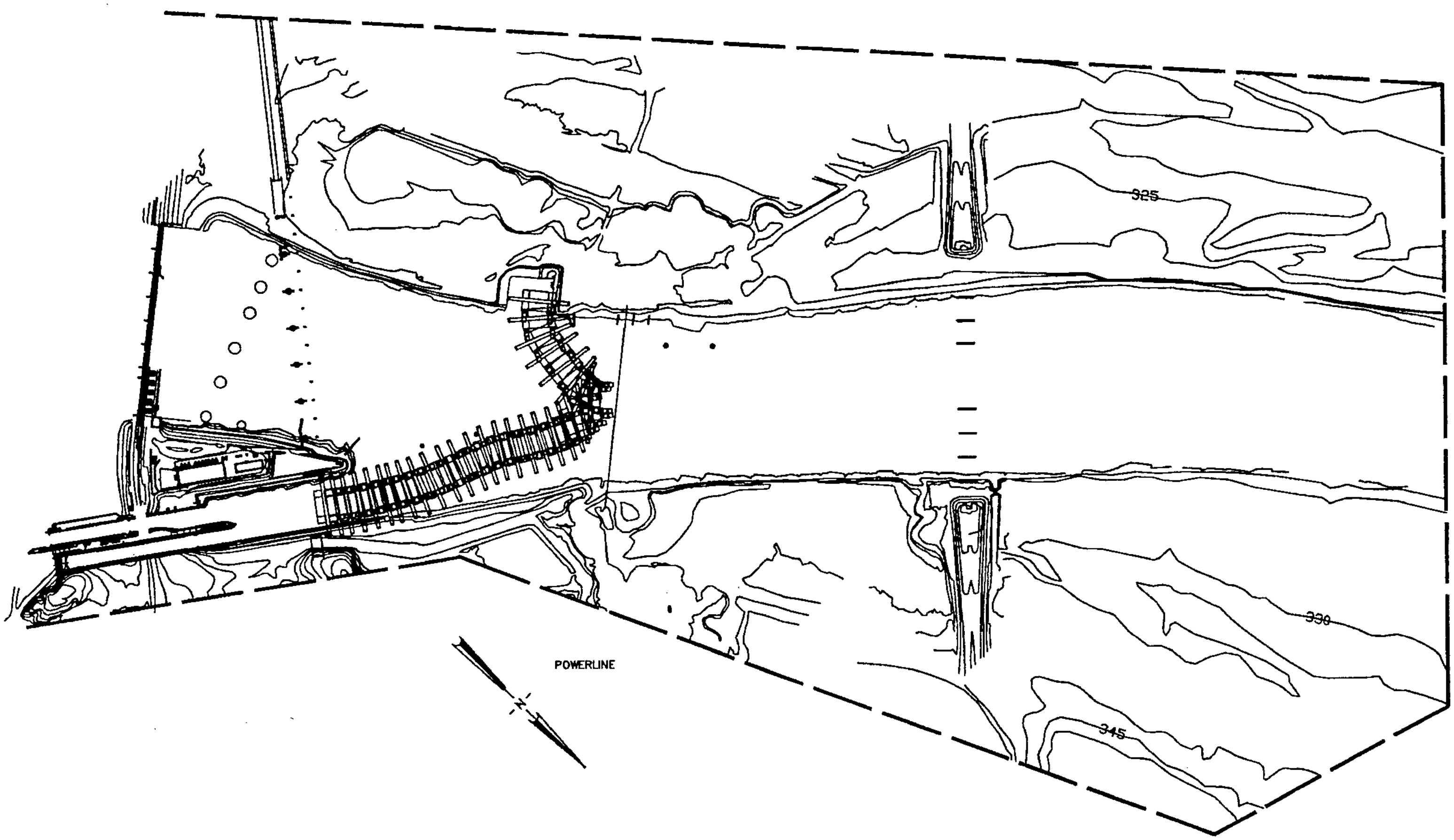
TOW TRACKS

PLAN B-2, FLOAT-IN

DISCHARGE: 301.5 to 303.0 TW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

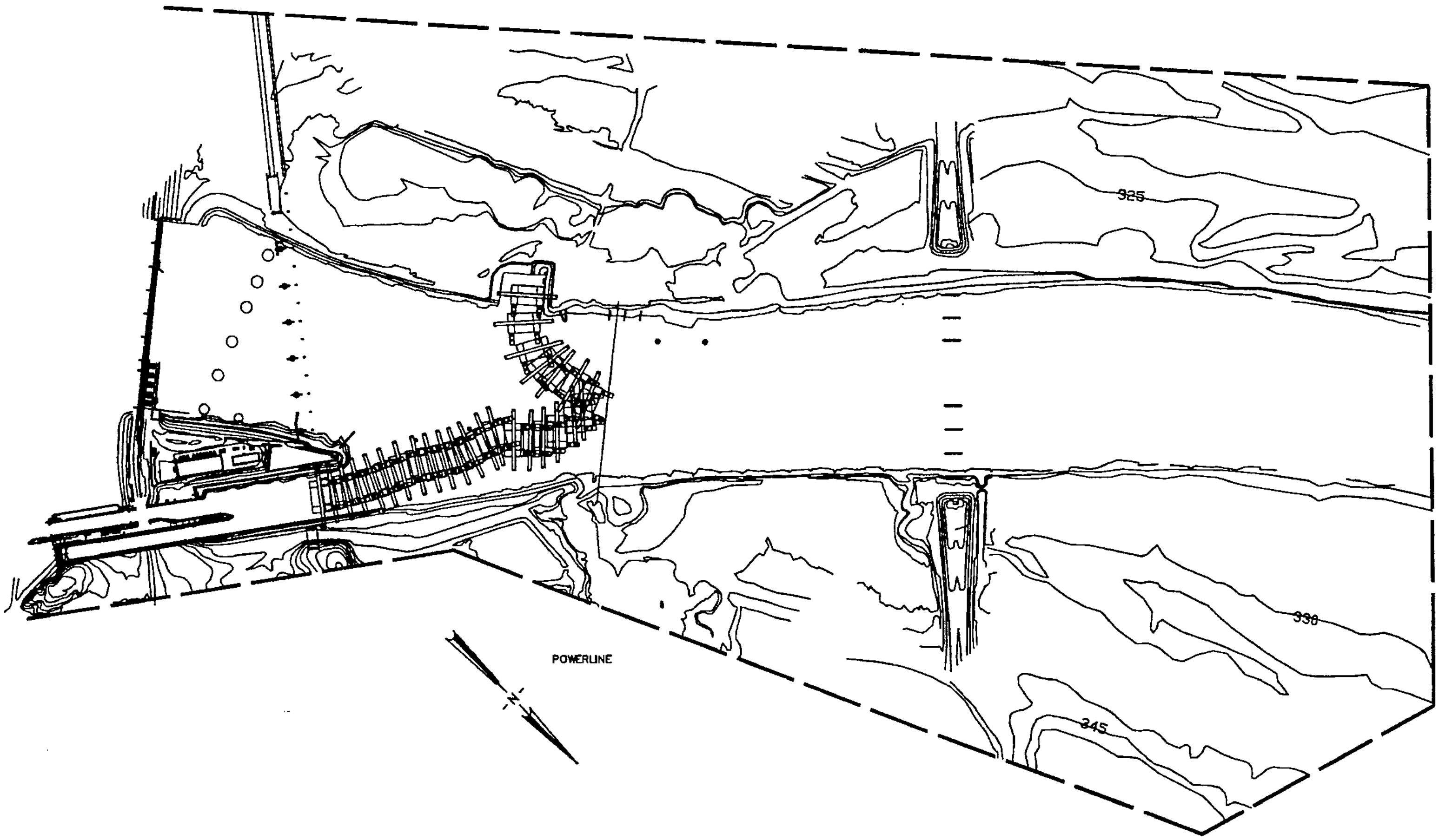
TOW TRACKS

PLAN B–2, FLOAT–IN

DISCHARGE: 303.0, NO FLOW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

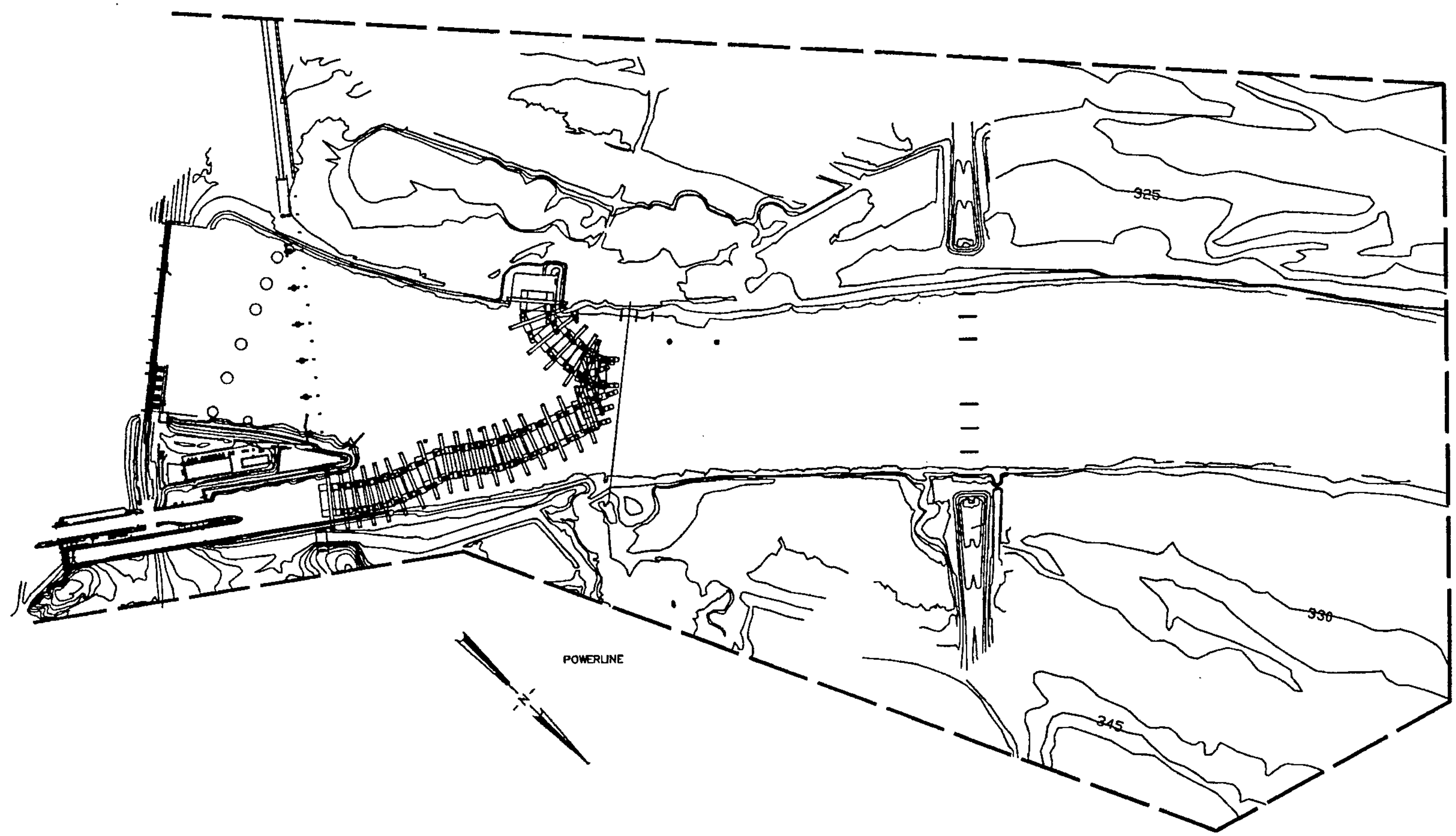
TOW TRACKS

PLAN B-2, FLOAT-IN, LINES

DISCHARGE: 300.0 TO 303.0 TW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT

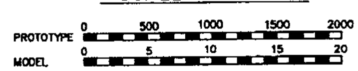


LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET



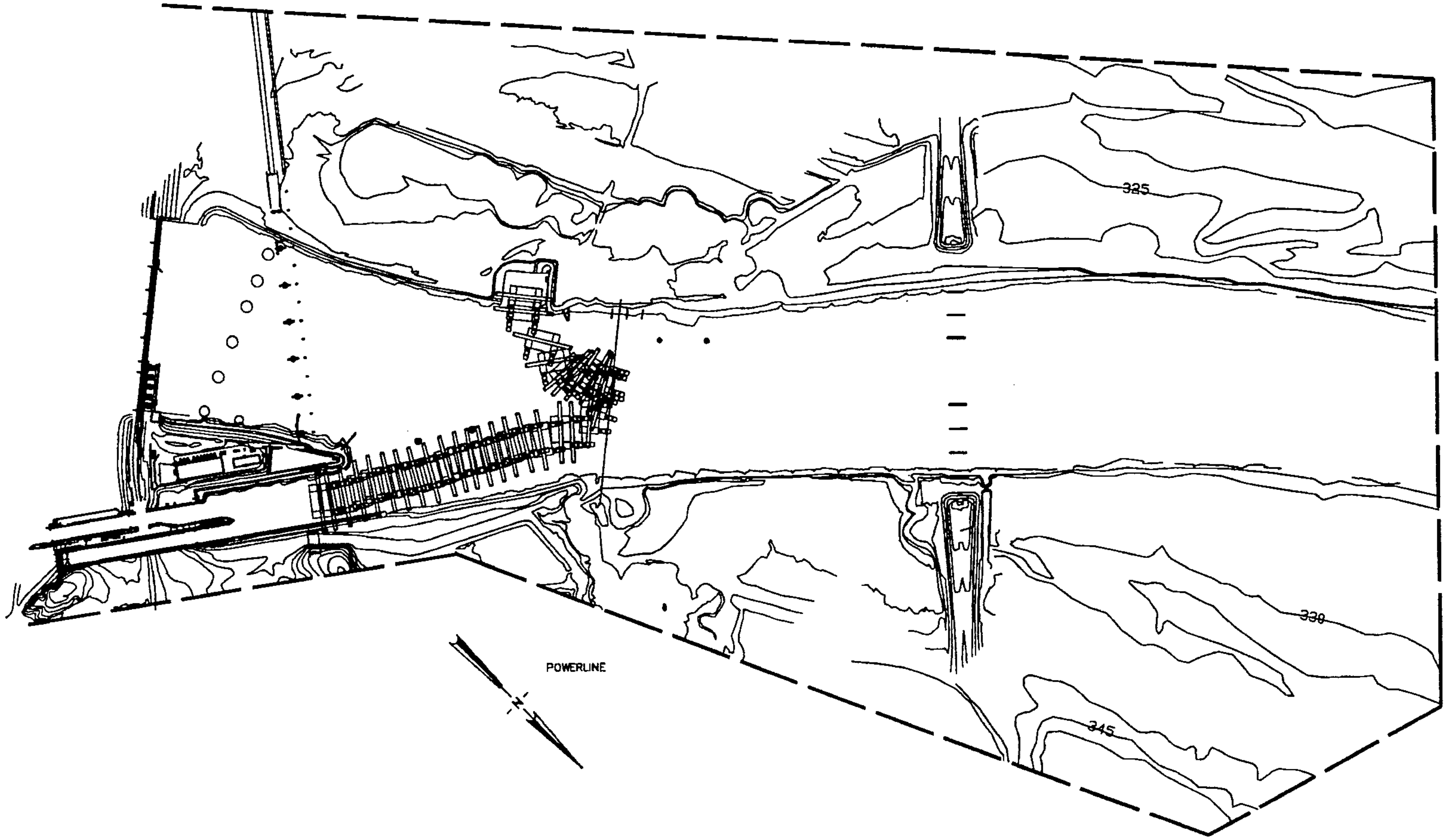
TOW TRACKS

PLAN B-2, FLOAT-IN, PILING

DISCHARGE: 300.0 TO 303.0 TW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT



LEGEND

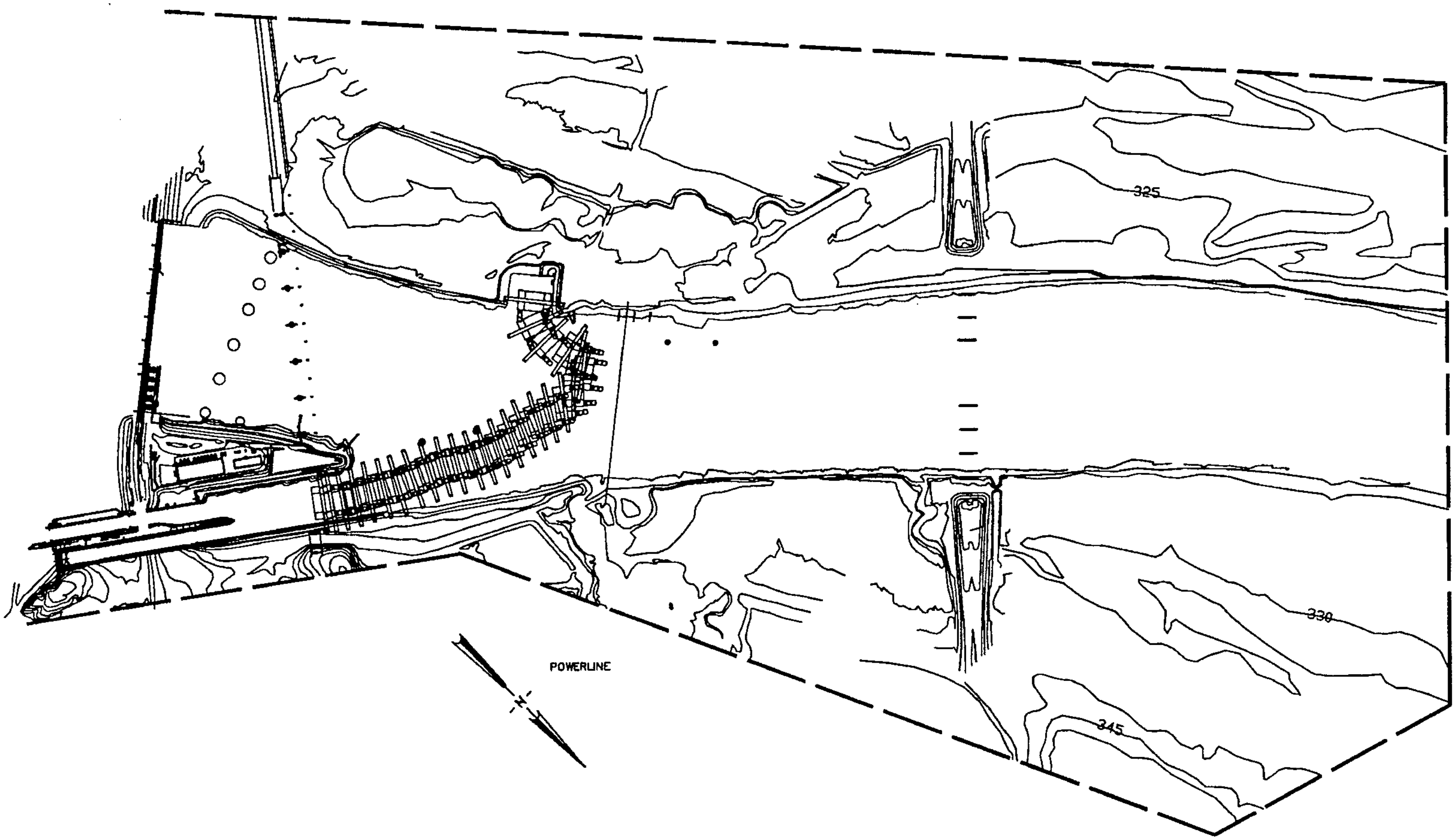
NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B–2, FLOAT–IN, LINES
DISCHARGE: 306.0 to 303.0 TW
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

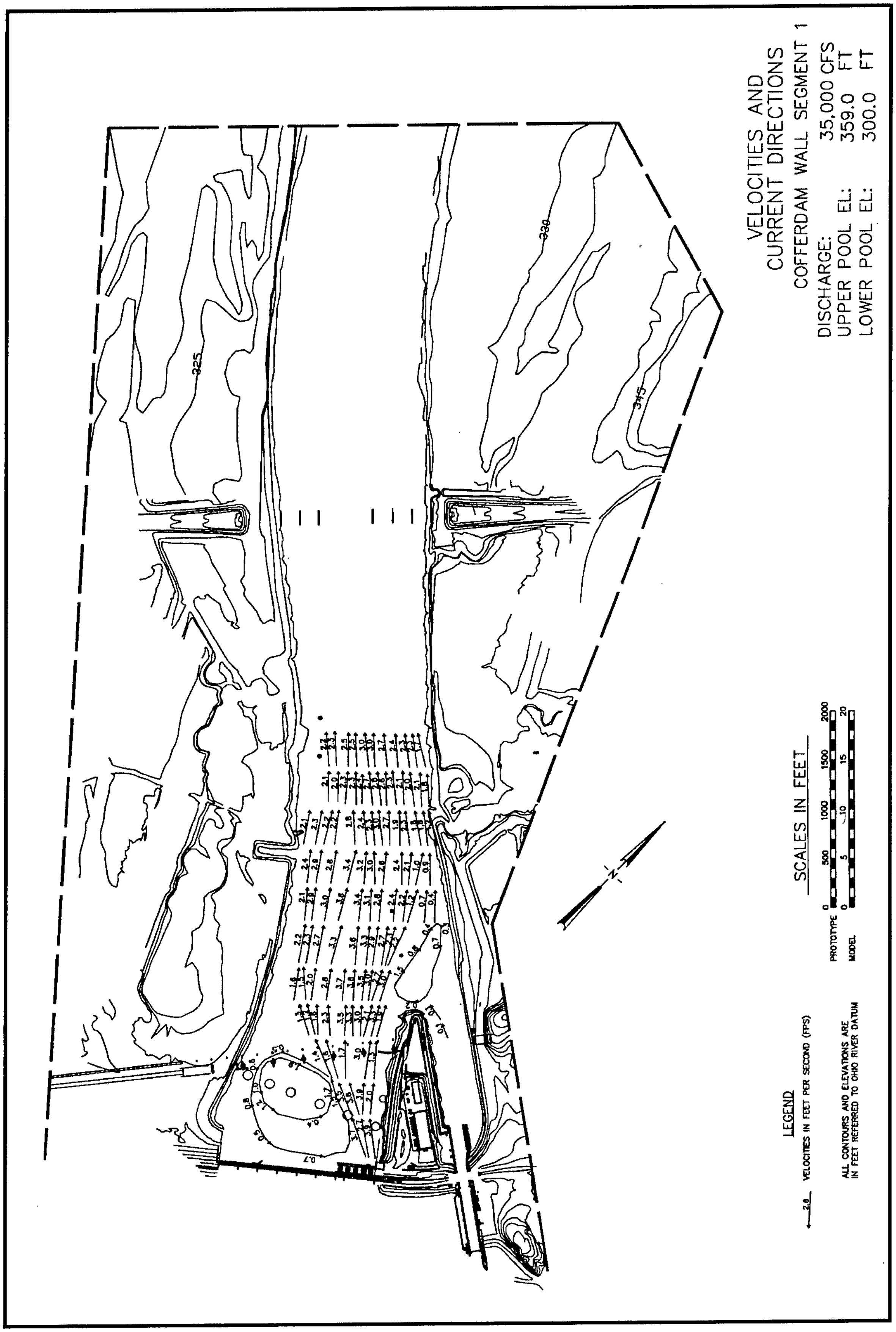
TOW TRACKS

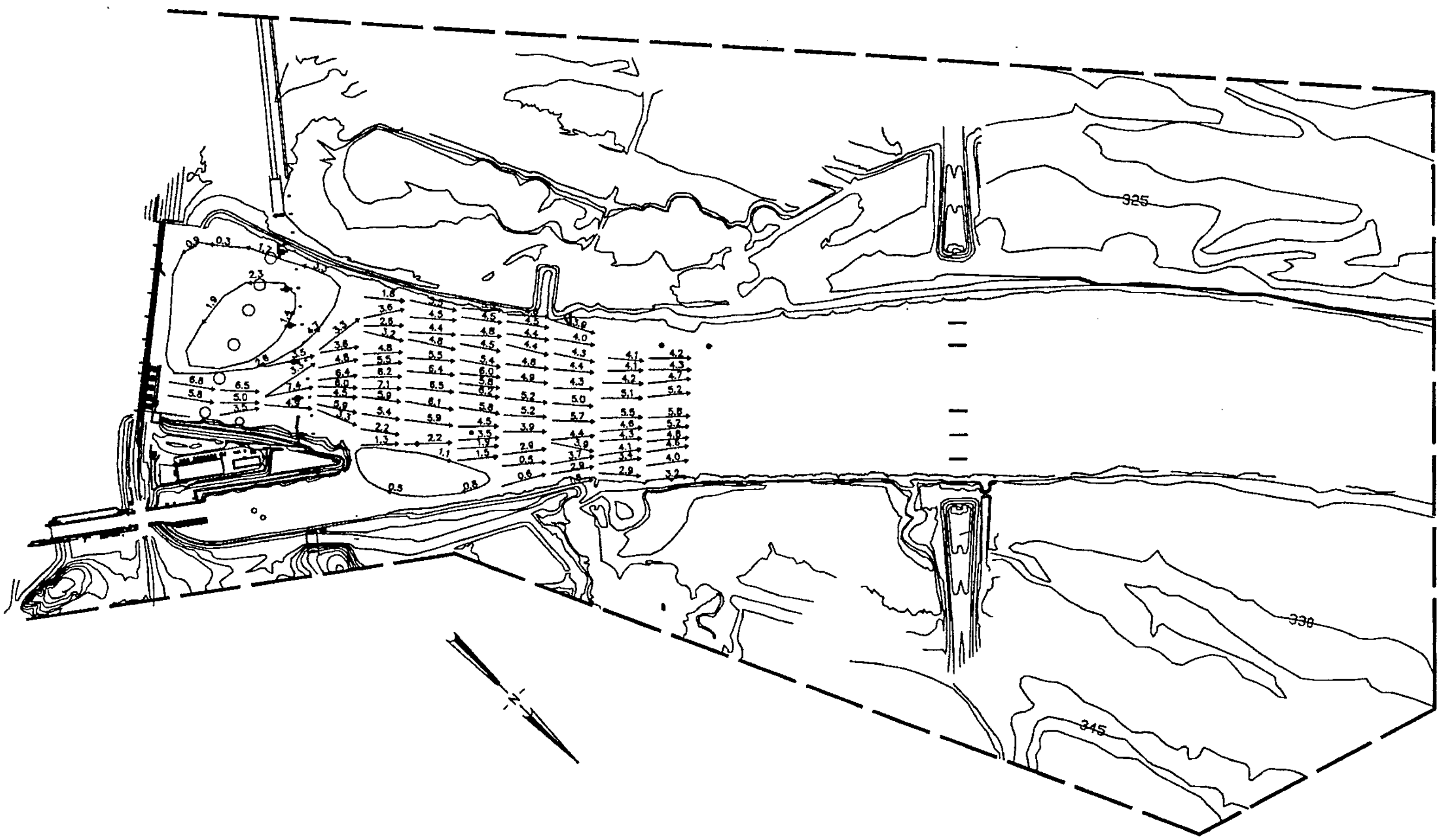
PLAN B-2, FLOAT-IN, PILING

DISCHARGE: 306.0 to 303.0 TW

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.0 FT


VELOCITIES AND
CURRENT DIRECTIONS
COFFERDAM WALL SEGMENT 1
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

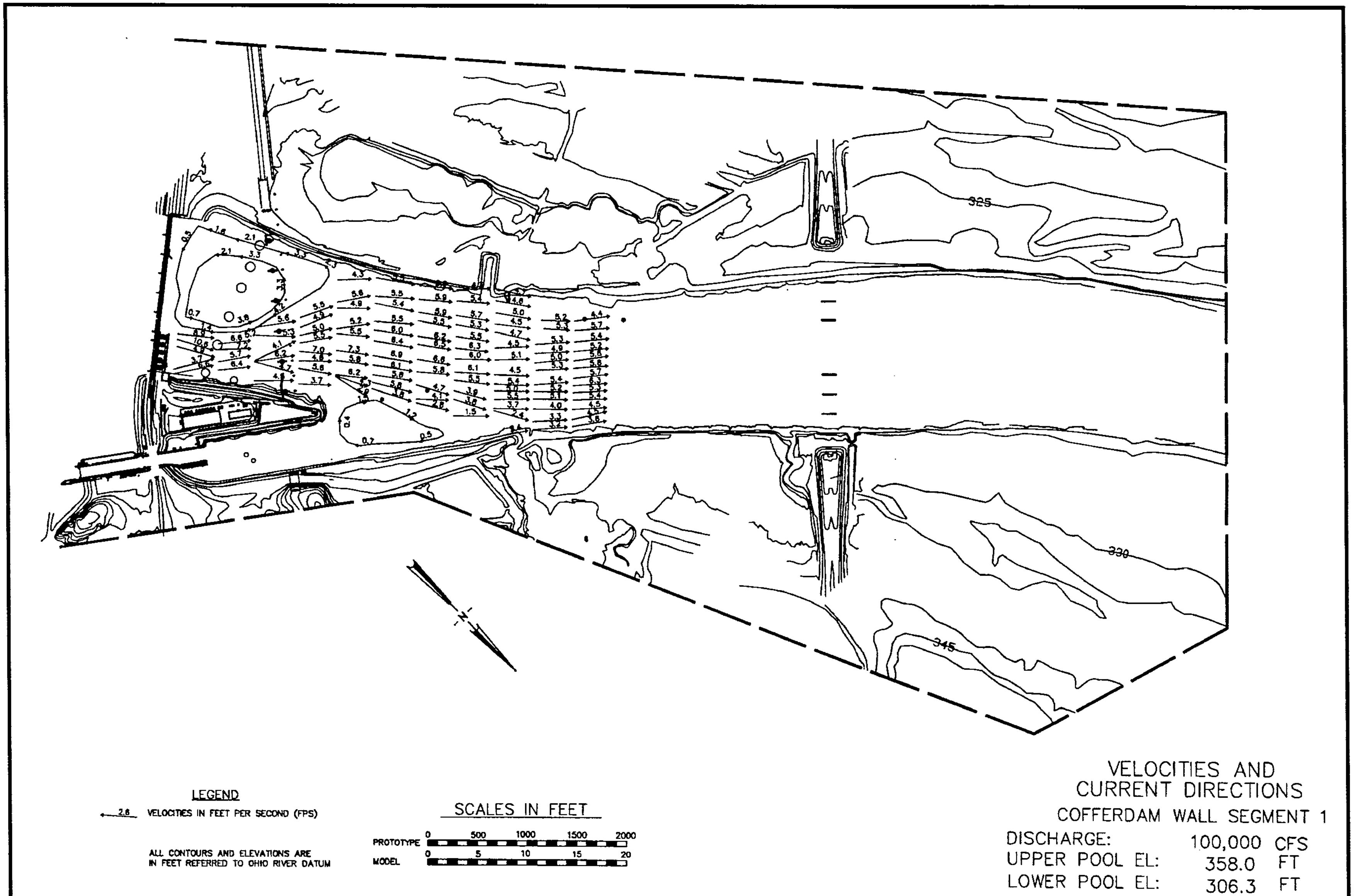
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

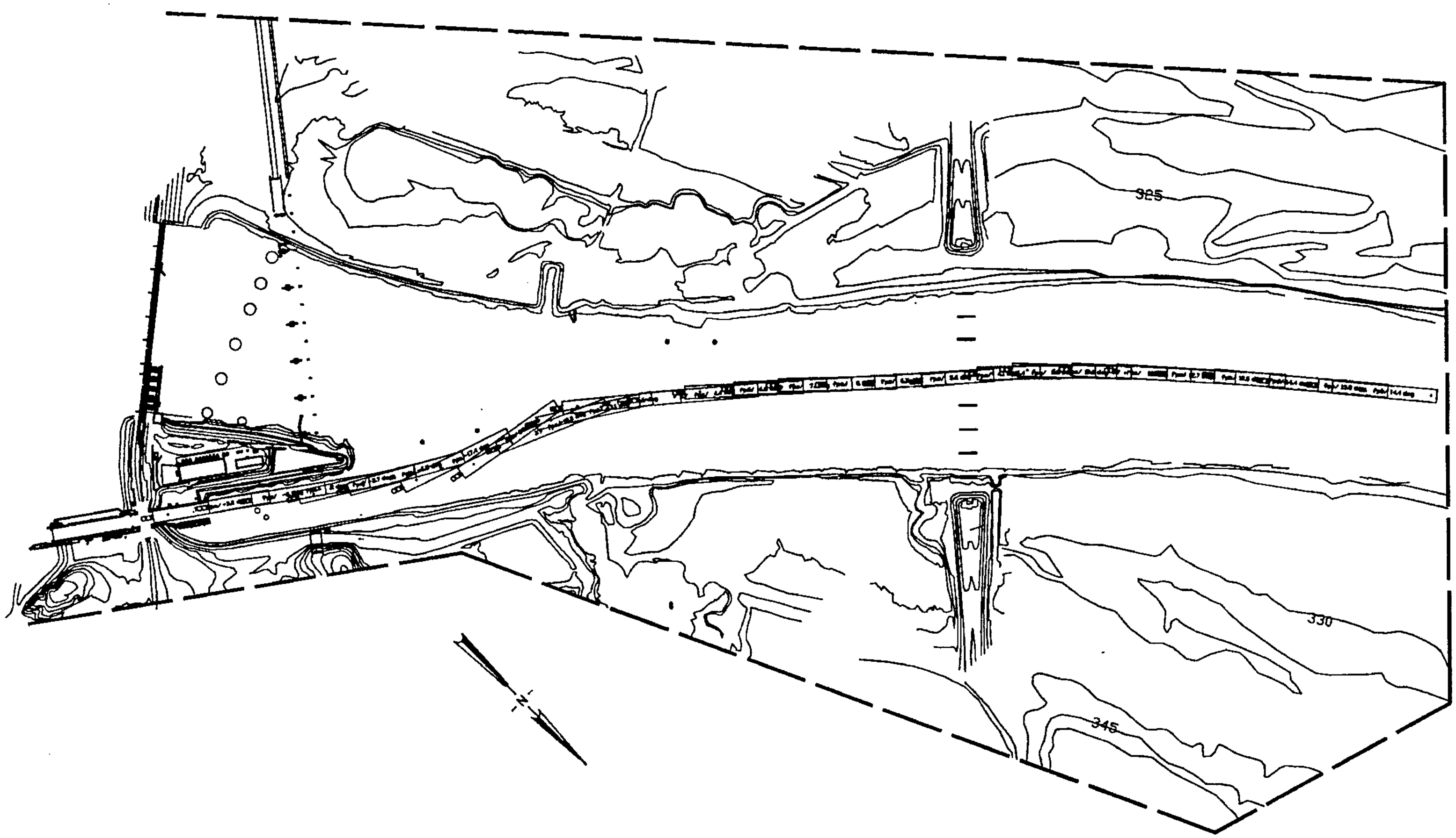
VELOCITIES AND CURRENT DIRECTIONS

COFFERDAM WALL SEGMENT 1

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



325
330
345
N
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
VELOCITIES AND CURRENT DIRECTIONS
COFFERDAM WALL SEGMENT 1
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

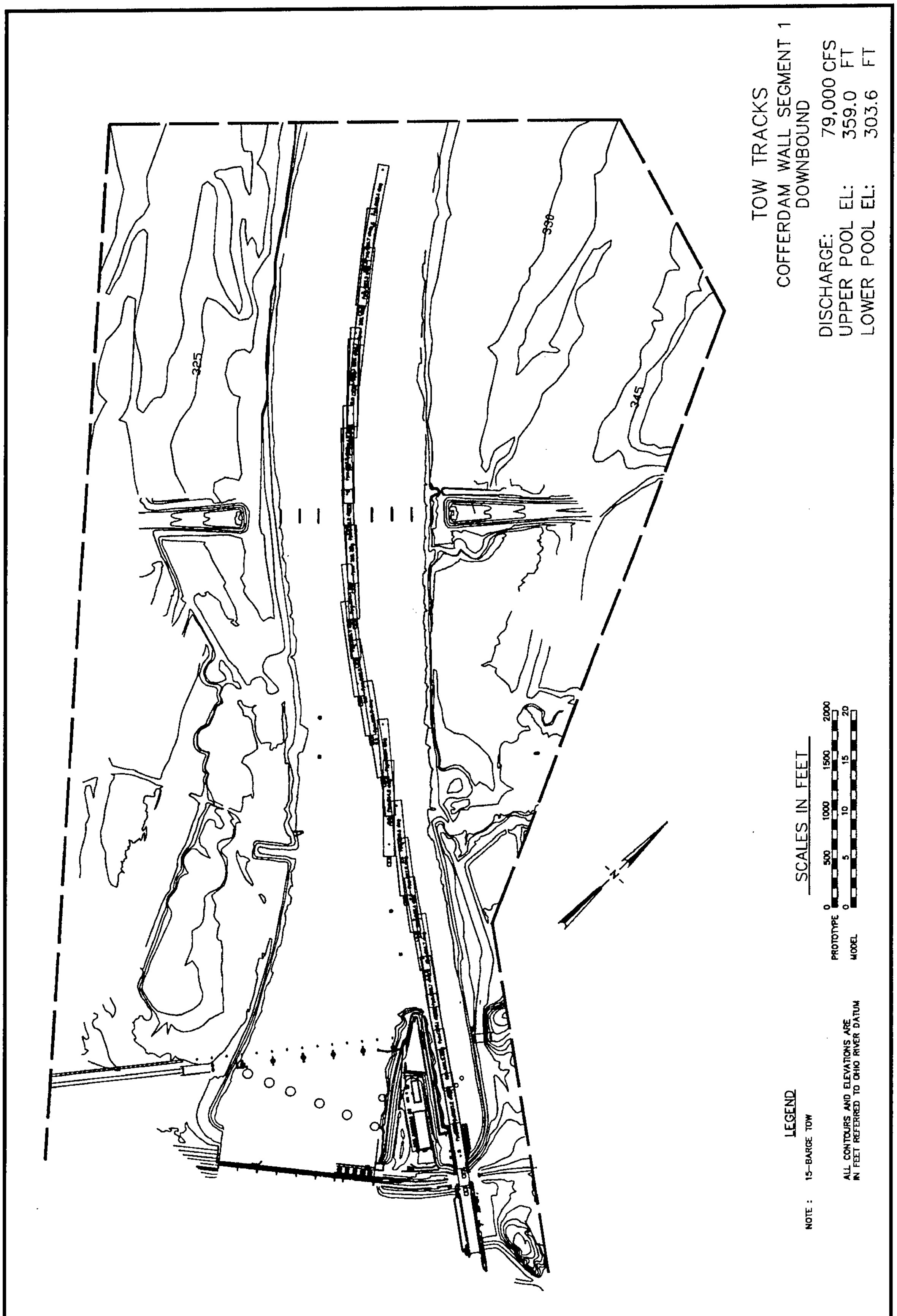
SCALES IN FEET

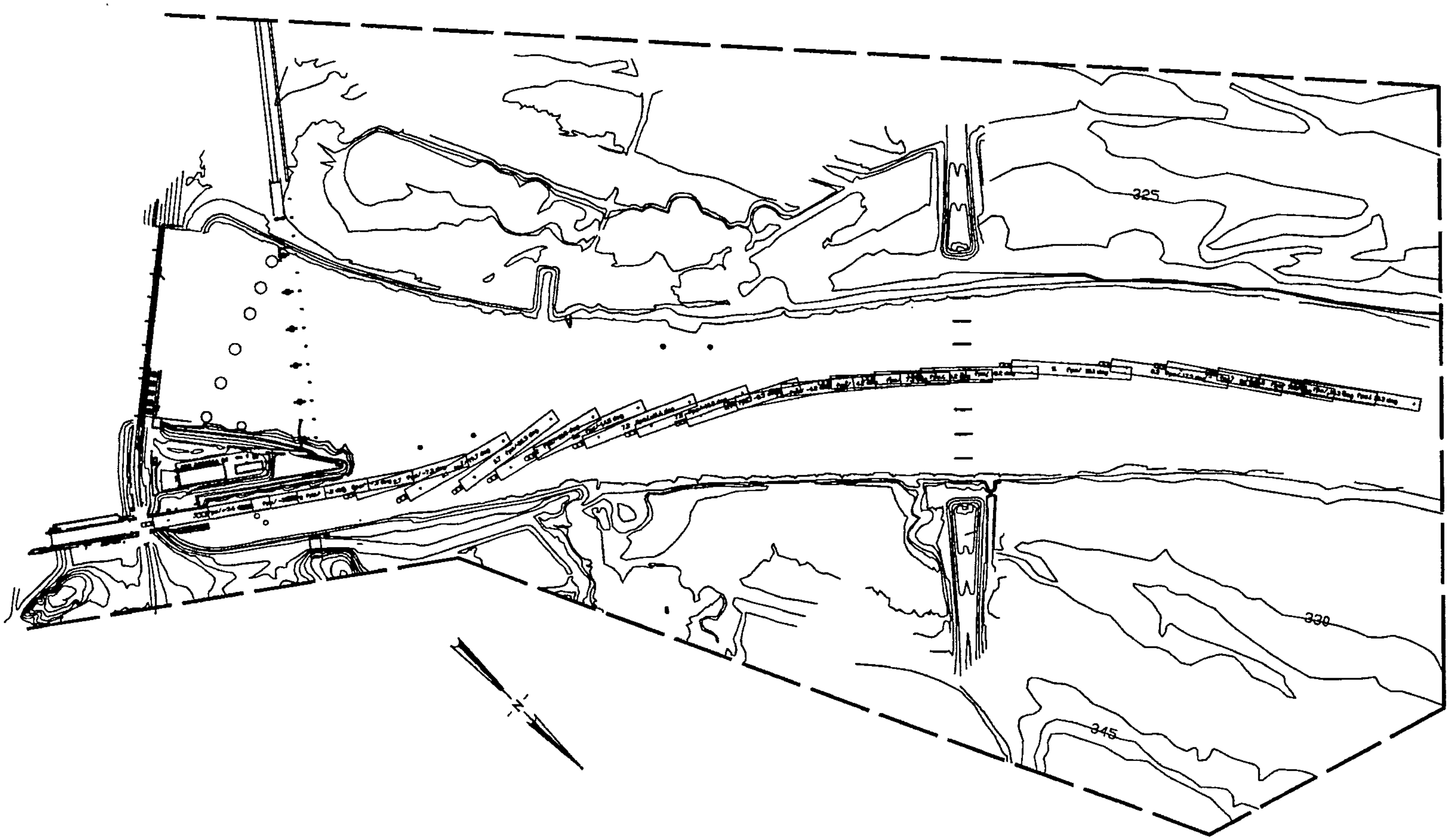
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 1
DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT


TOW TRACKS
COFFERDAM WALL SEGMENT 1
DOWNBOUND
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

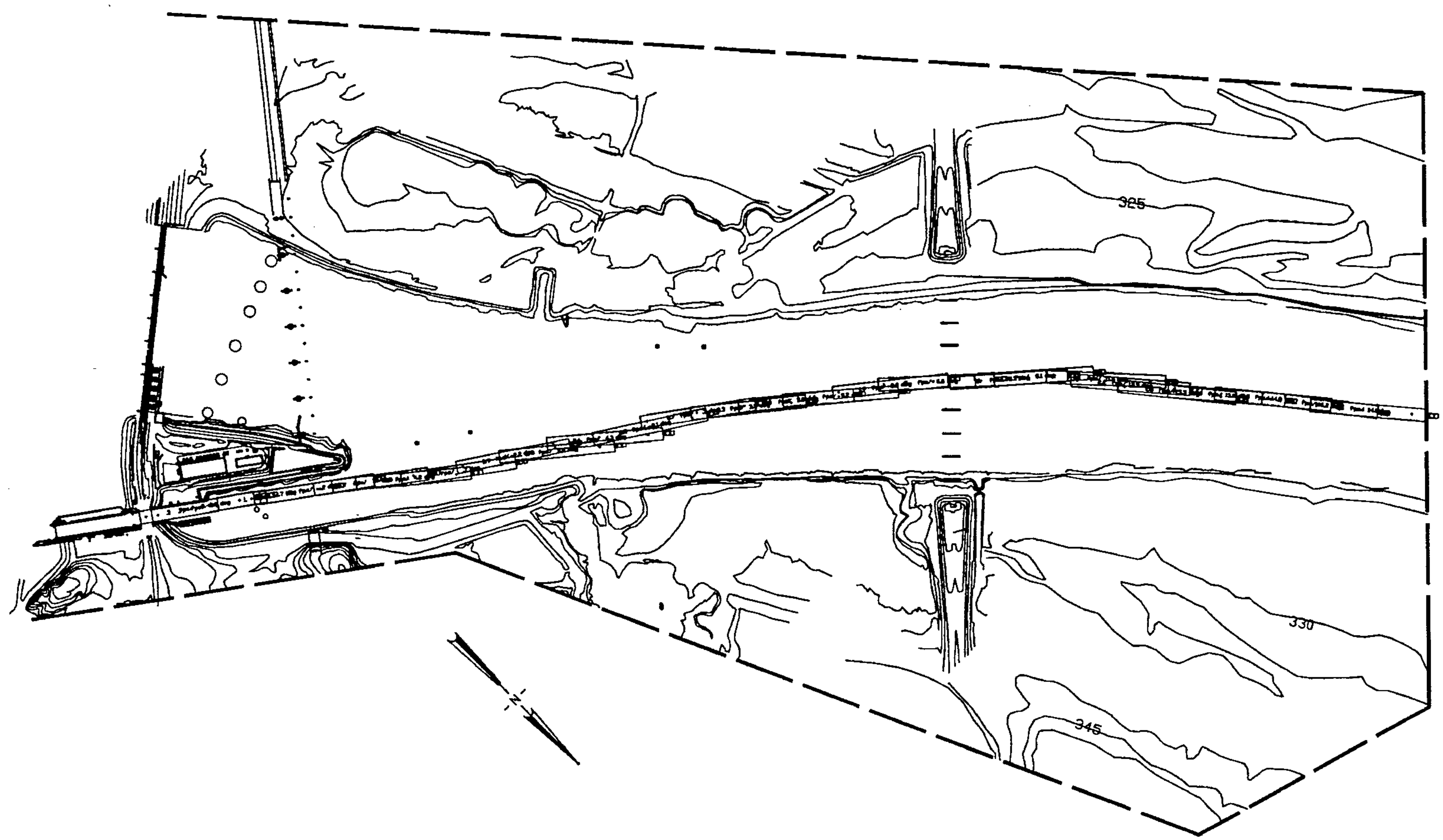
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 1
DOWNBOUND

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

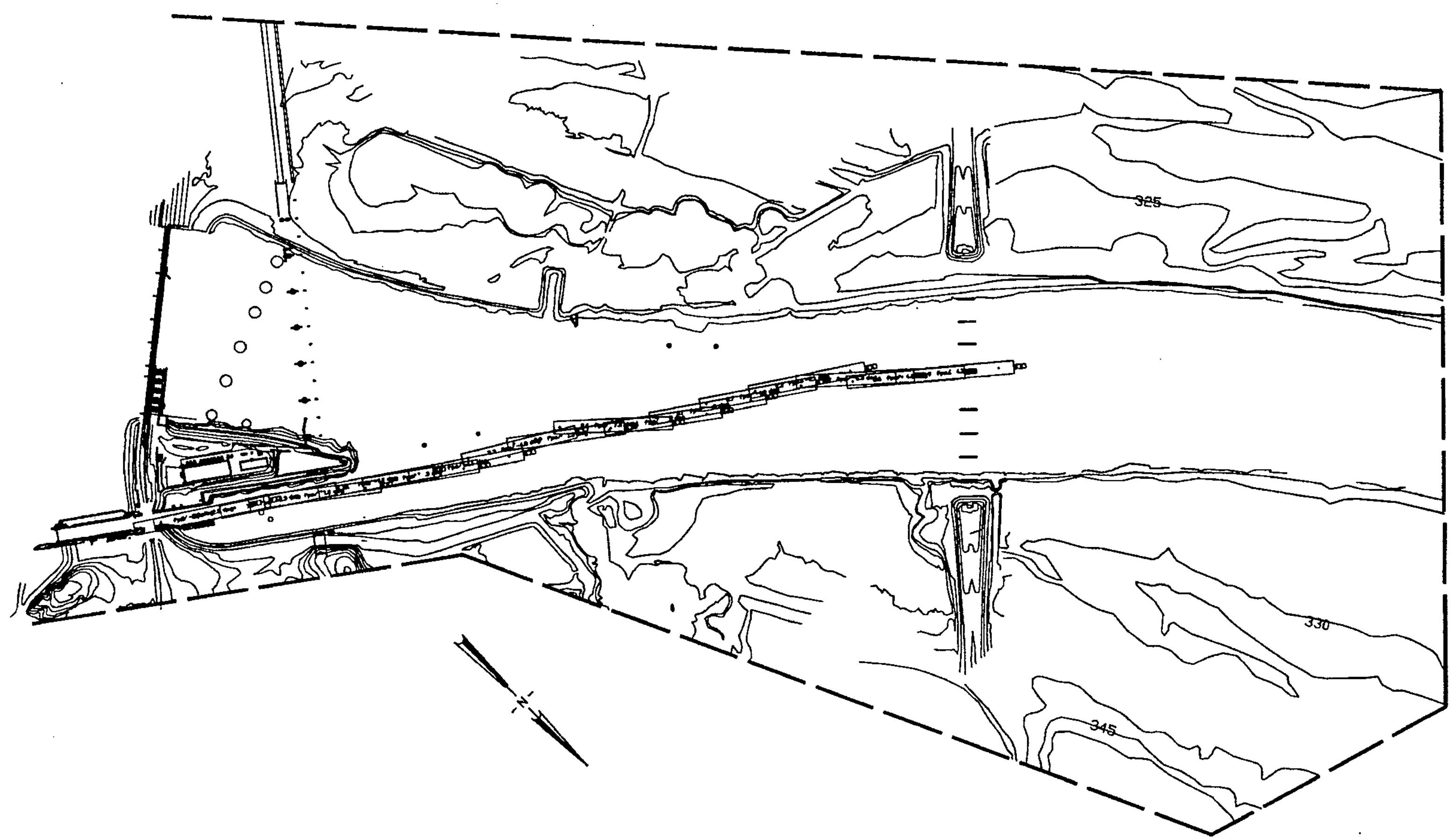
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 1
UPBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



TOW TRACKS
COFFERDAM WALL SEGMENT 1
UPBOUND WITH CAMELS

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT

LEGEND

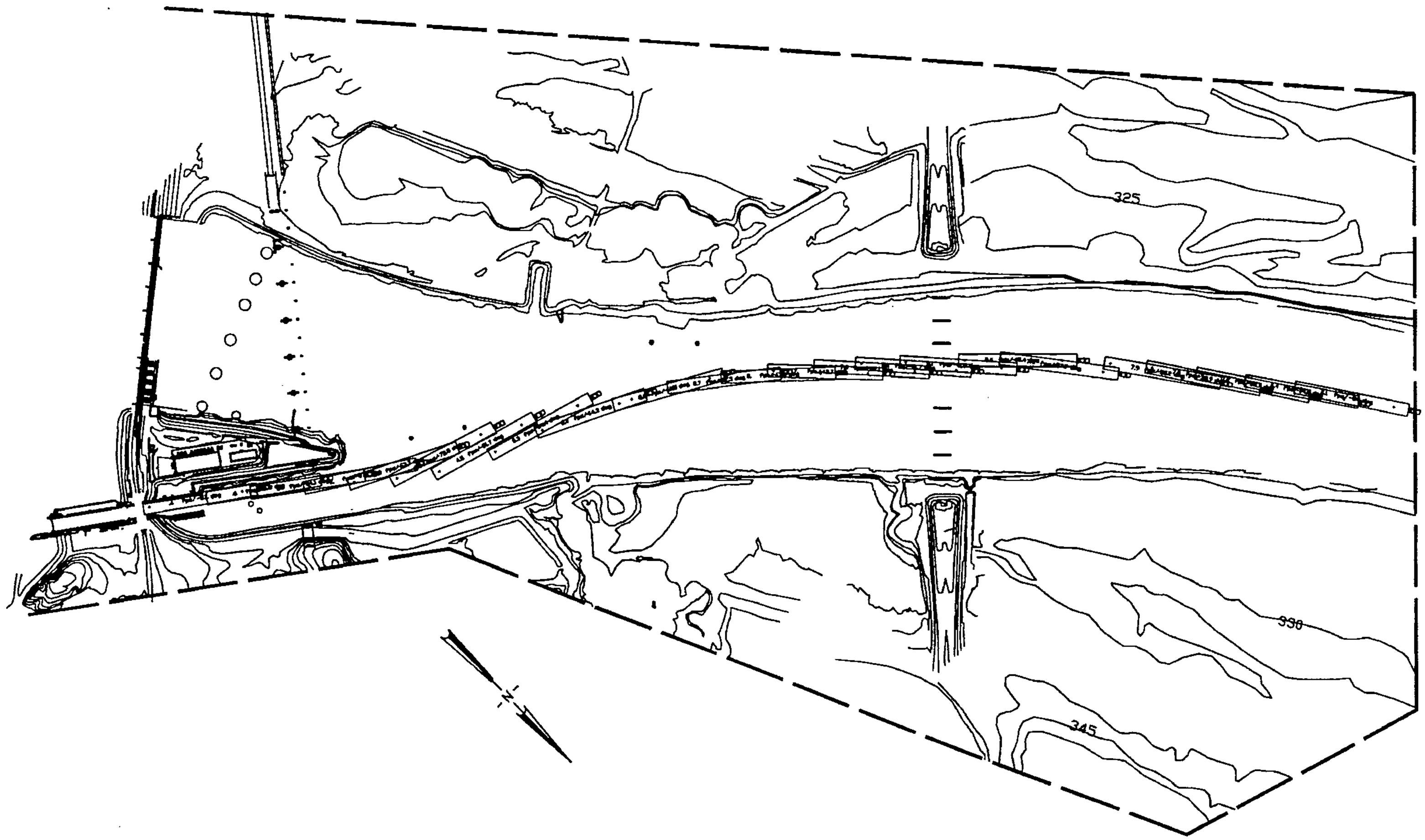
NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

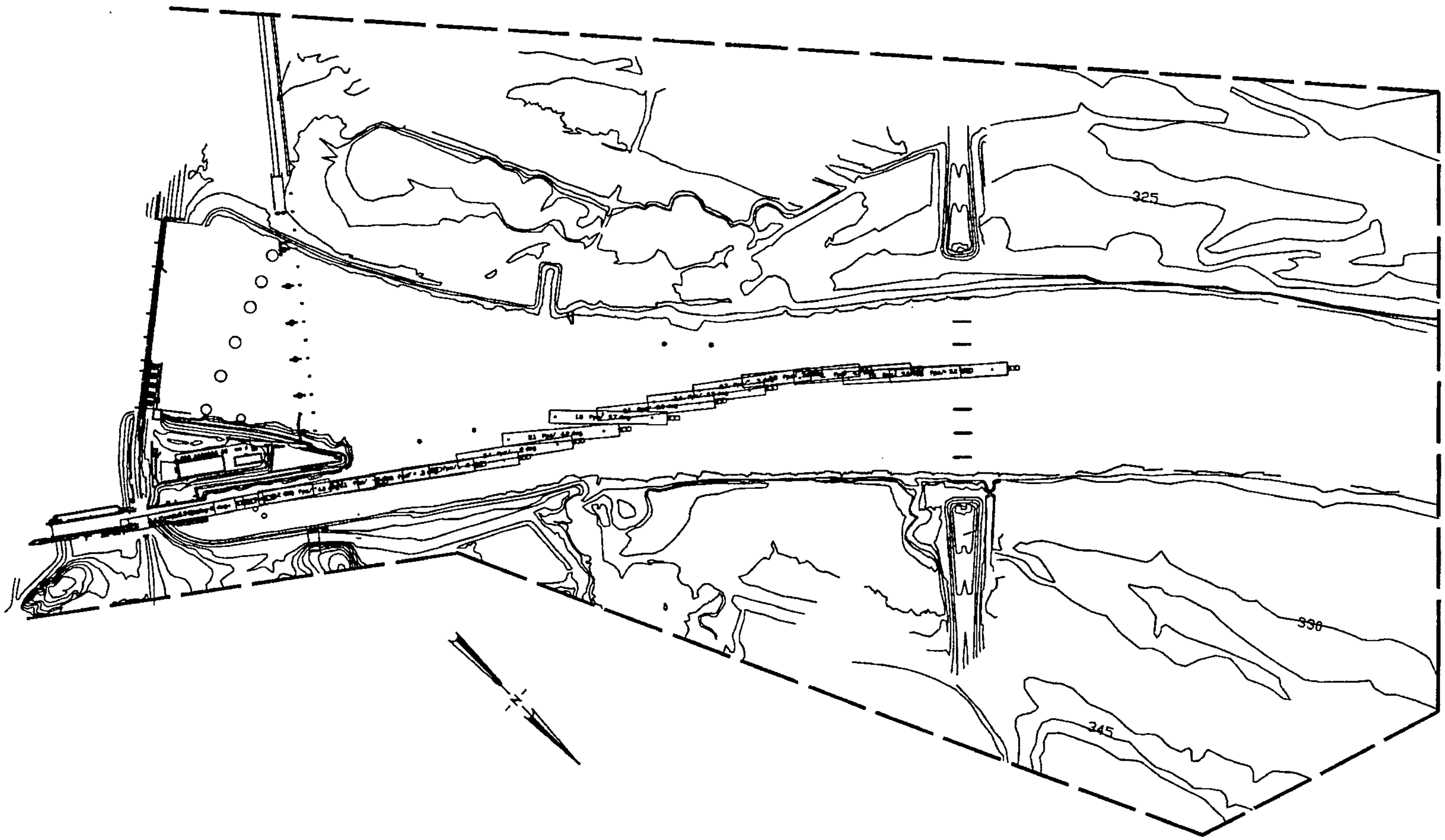
COFFERDAM WALL SEGMENT 1

UPBOUND

DISCHARGE: 79,000 CFS

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.6 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

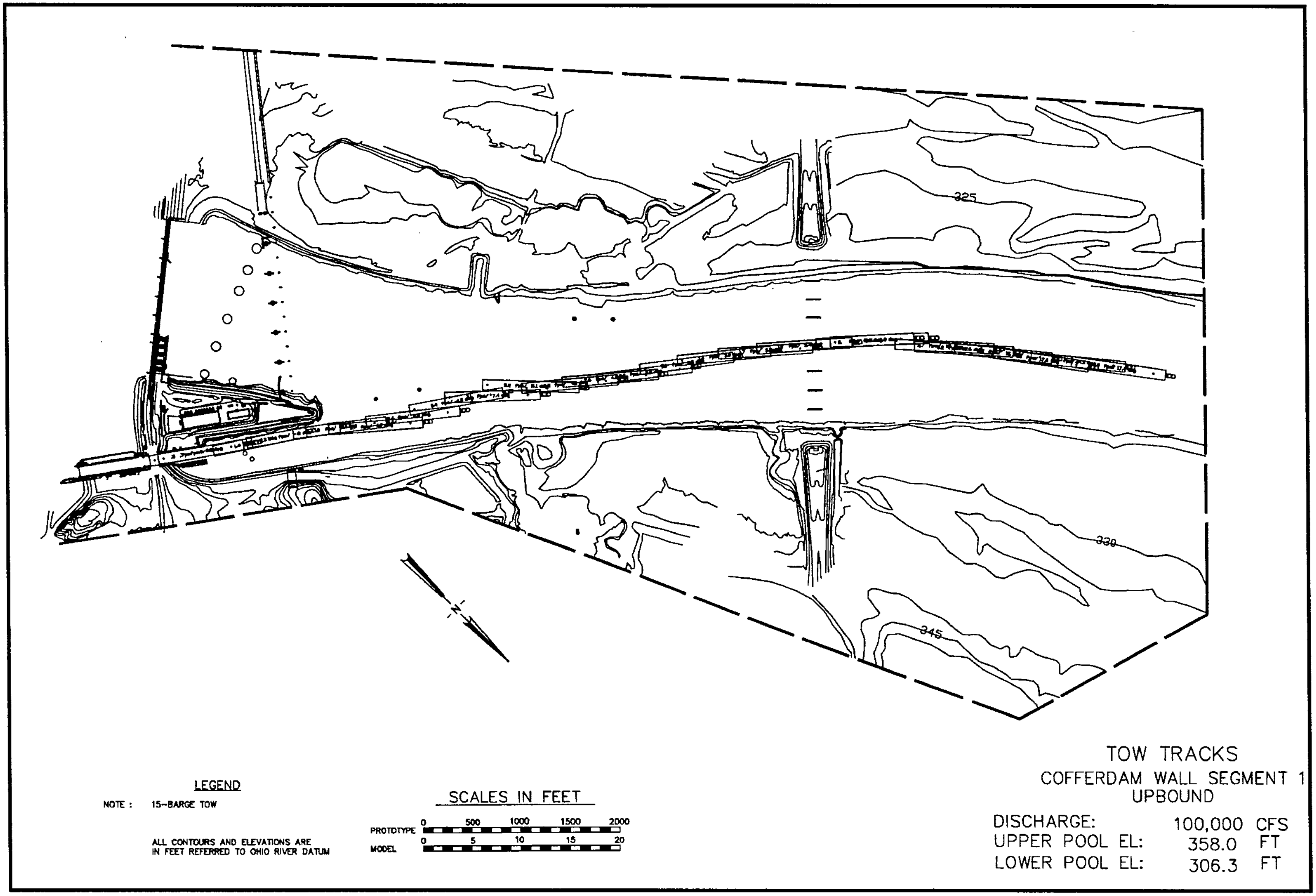
COFFERDAM WALL SEGMENT 1

UPBOUND WITH CAMELS

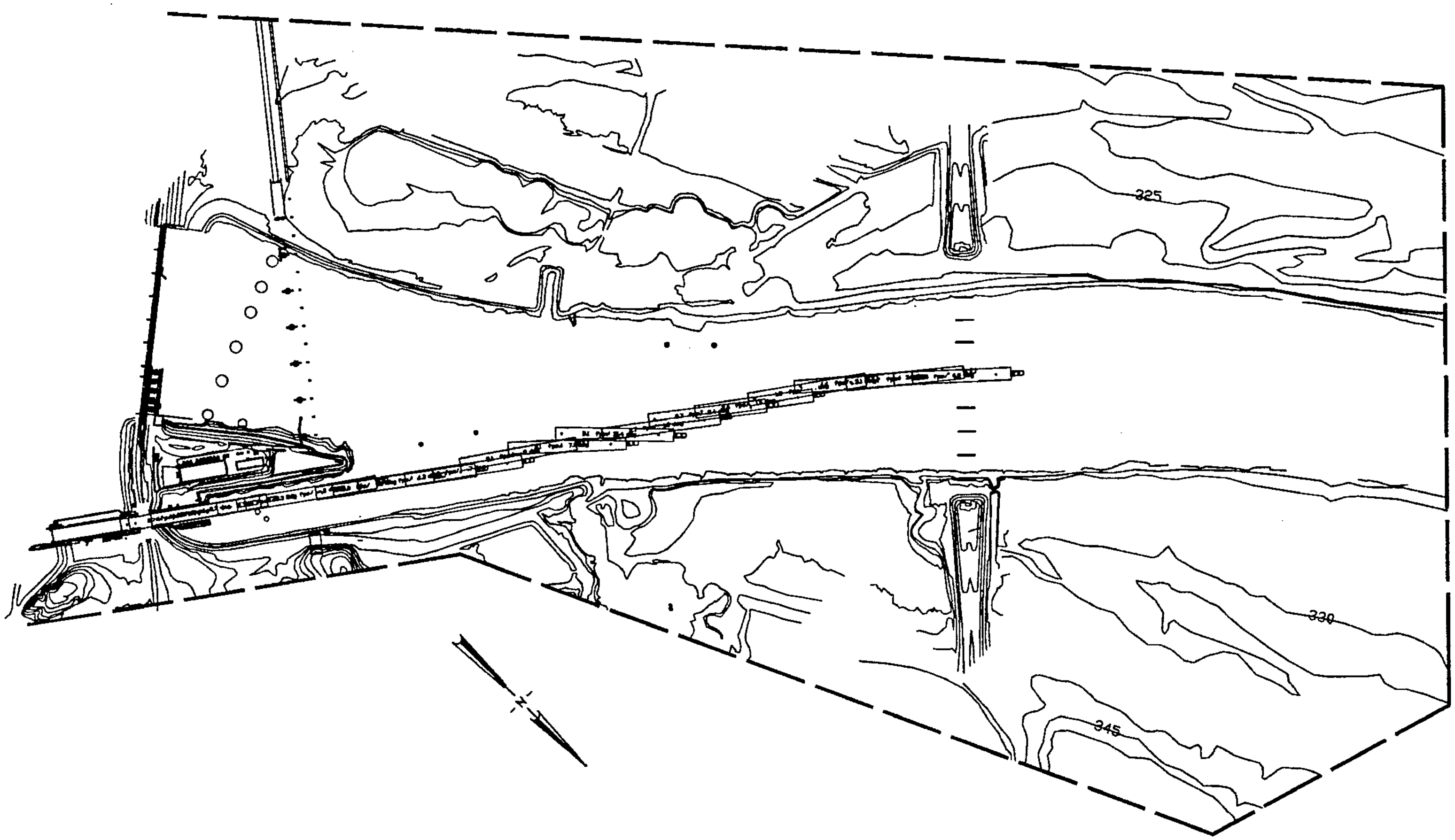
DISCHARGE: 79,000 CFS

UPPER POOL EL: 359.0 FT

LOWER POOL EL: 303.6 FT



325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
COFFERDAM WALL SEGMENT 1
UPBOUND
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

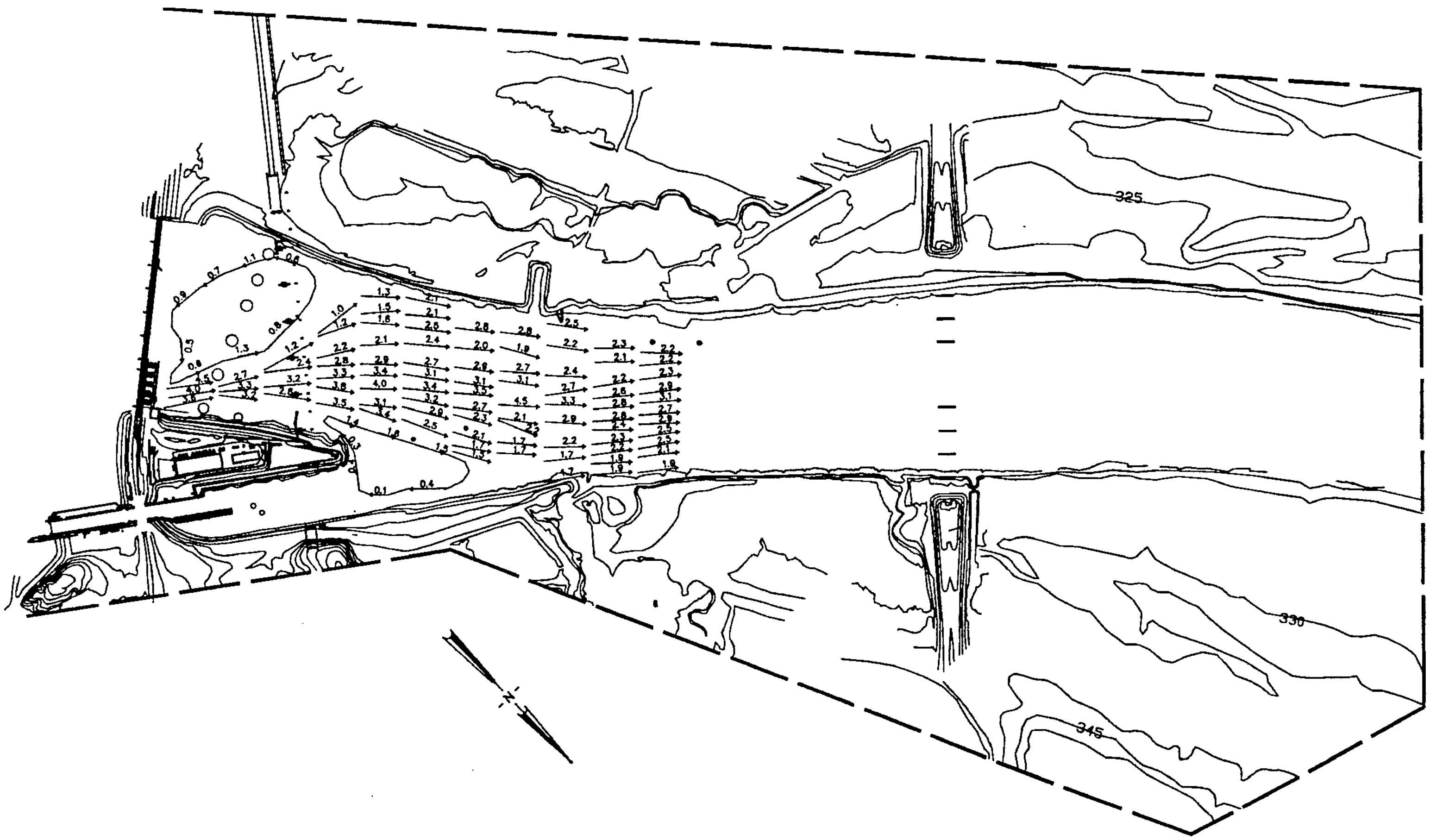
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS

COFFERDAM WALL SEGMENT 1
UPBOUND WITH CAMELS

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

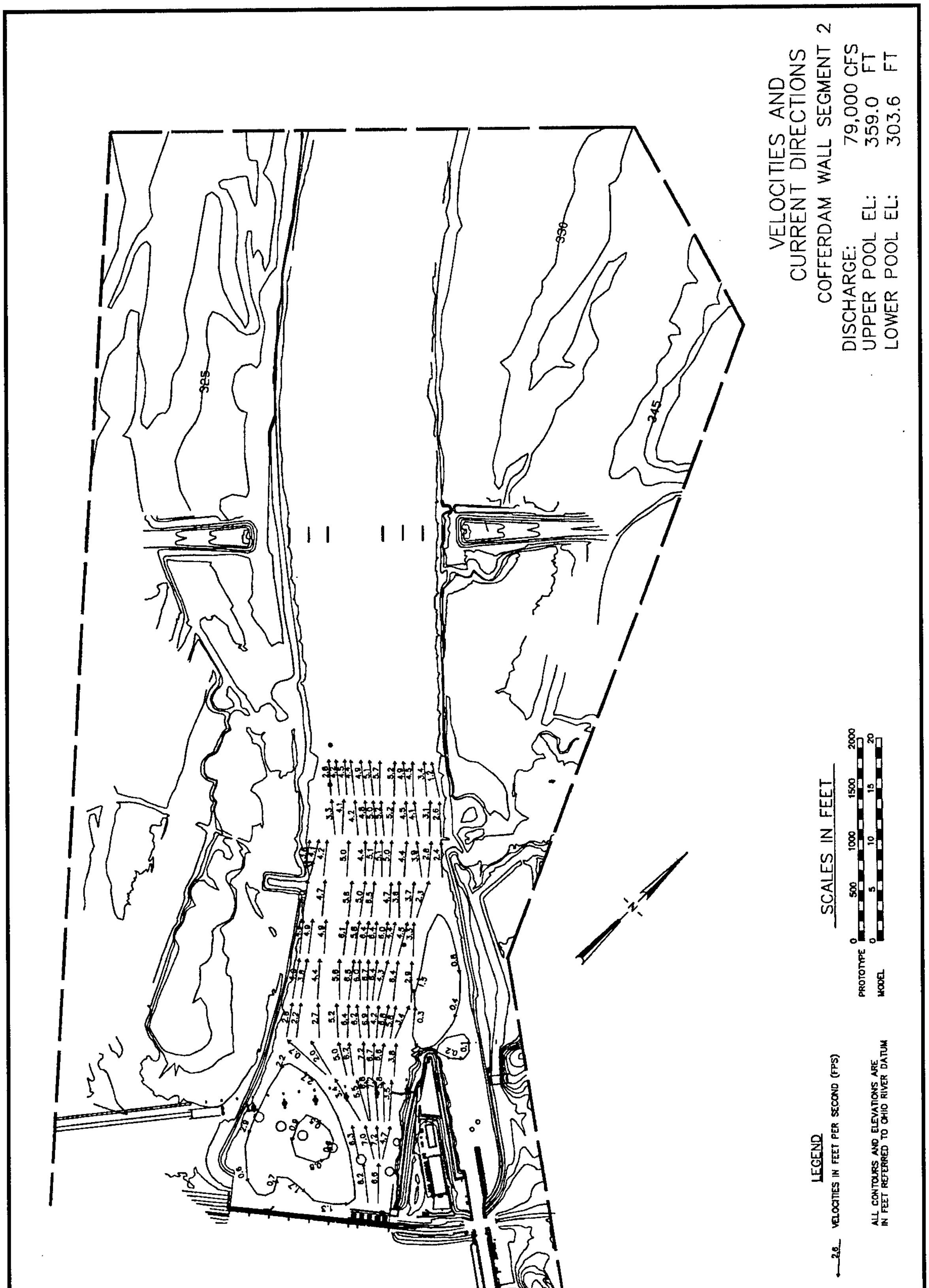
PROTOTYPE 0 500 1000 1500 2000

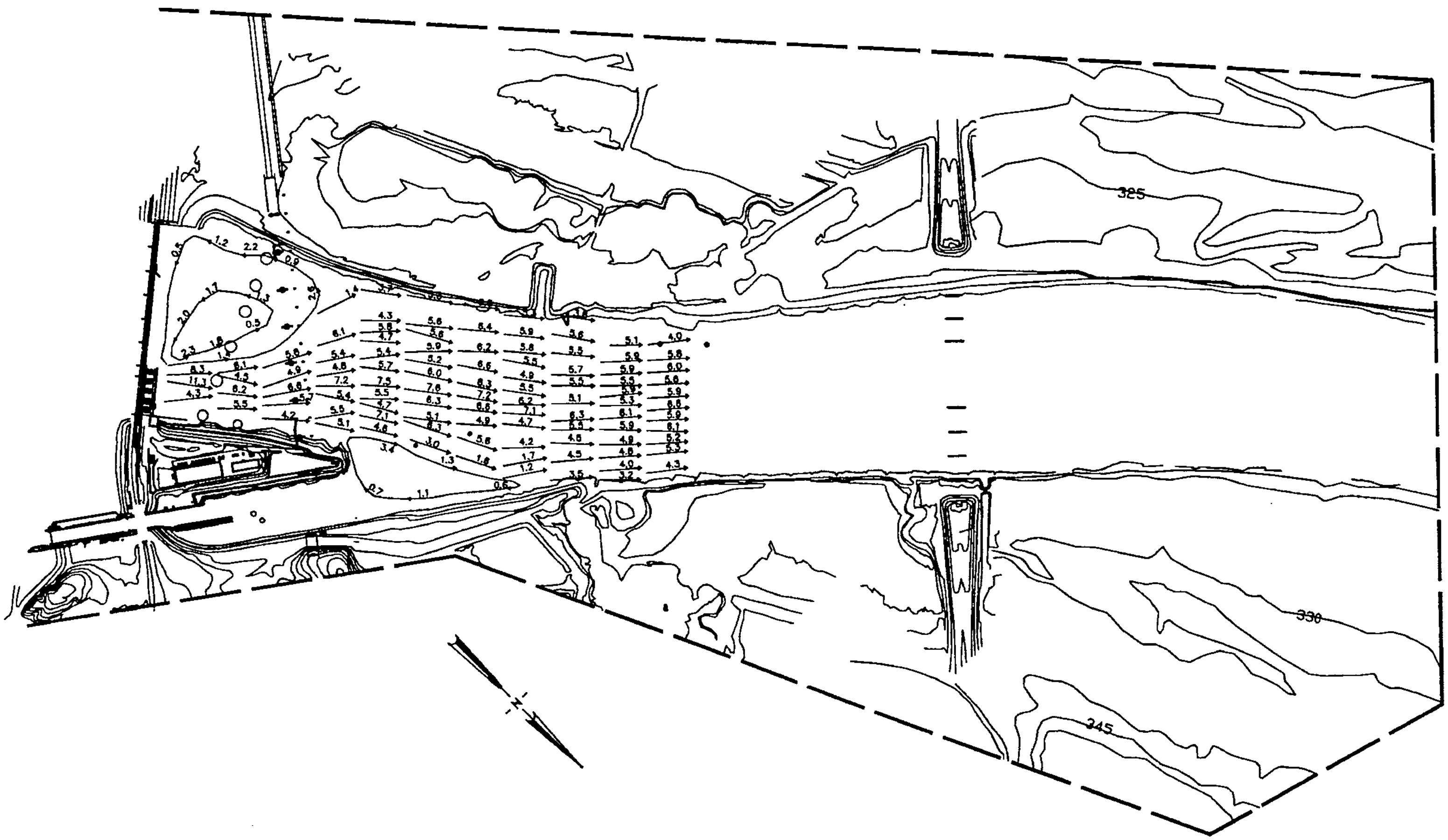
MODEL 0 5 10 15 20

VELOCITIES AND
CURRENT DIRECTIONS

COFFERDAM WALL SEGMENT 2

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT


VELOCITIES AND
CURRENT DIRECTIONS
COFFERDAM WALL SEGMENT 2
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT
SCALES IN FEET
PROTOTYPE
MODEL
LEGEND
VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

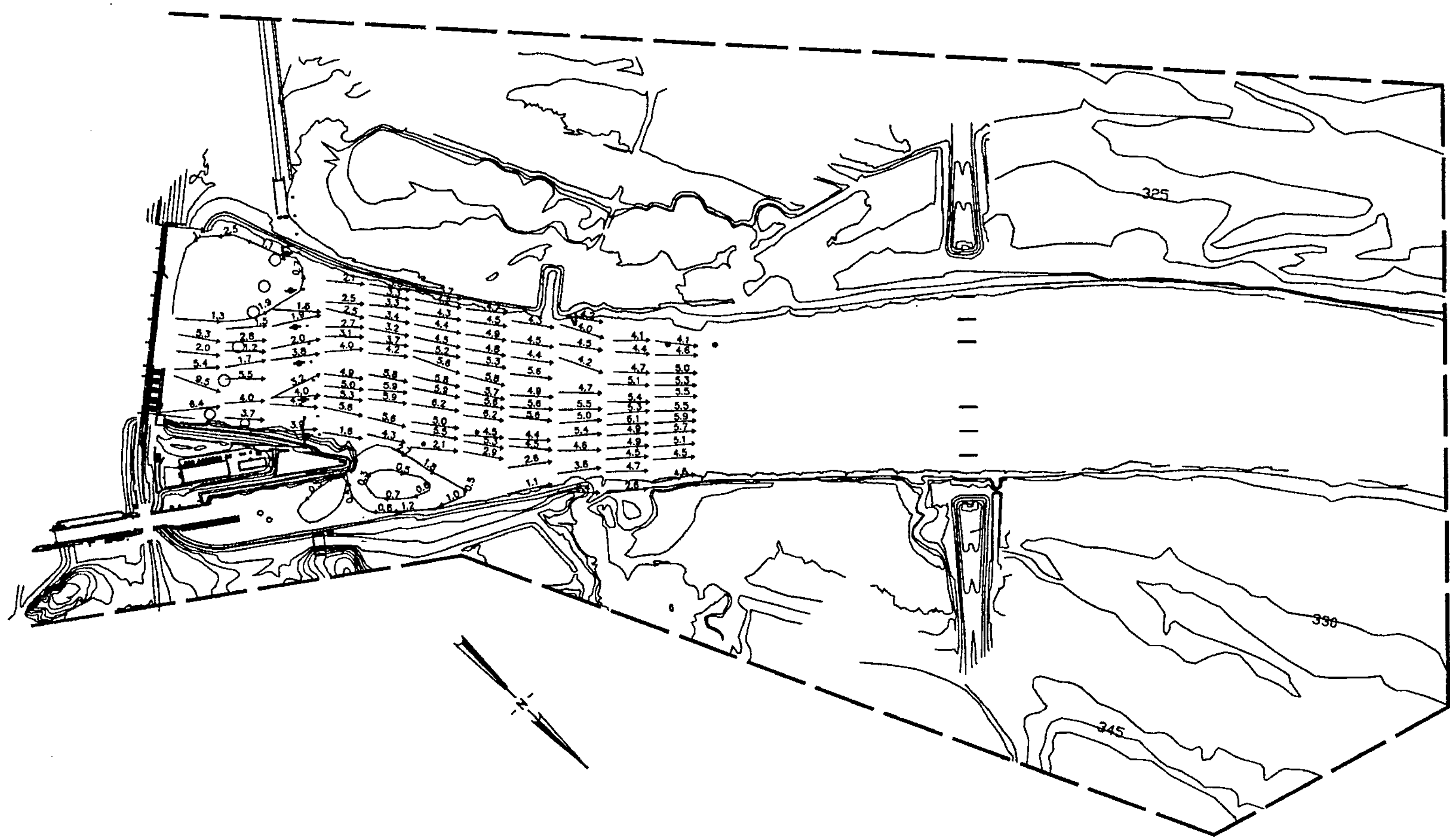
VELOCITIES AND CURRENT DIRECTIONS

COFFERDAM WALL SEGMENT 2

DISCHARGE: 100,000 CFS

UPPER POOL EL: 358.0 FT

LOWER POOL EL: 306.3 FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

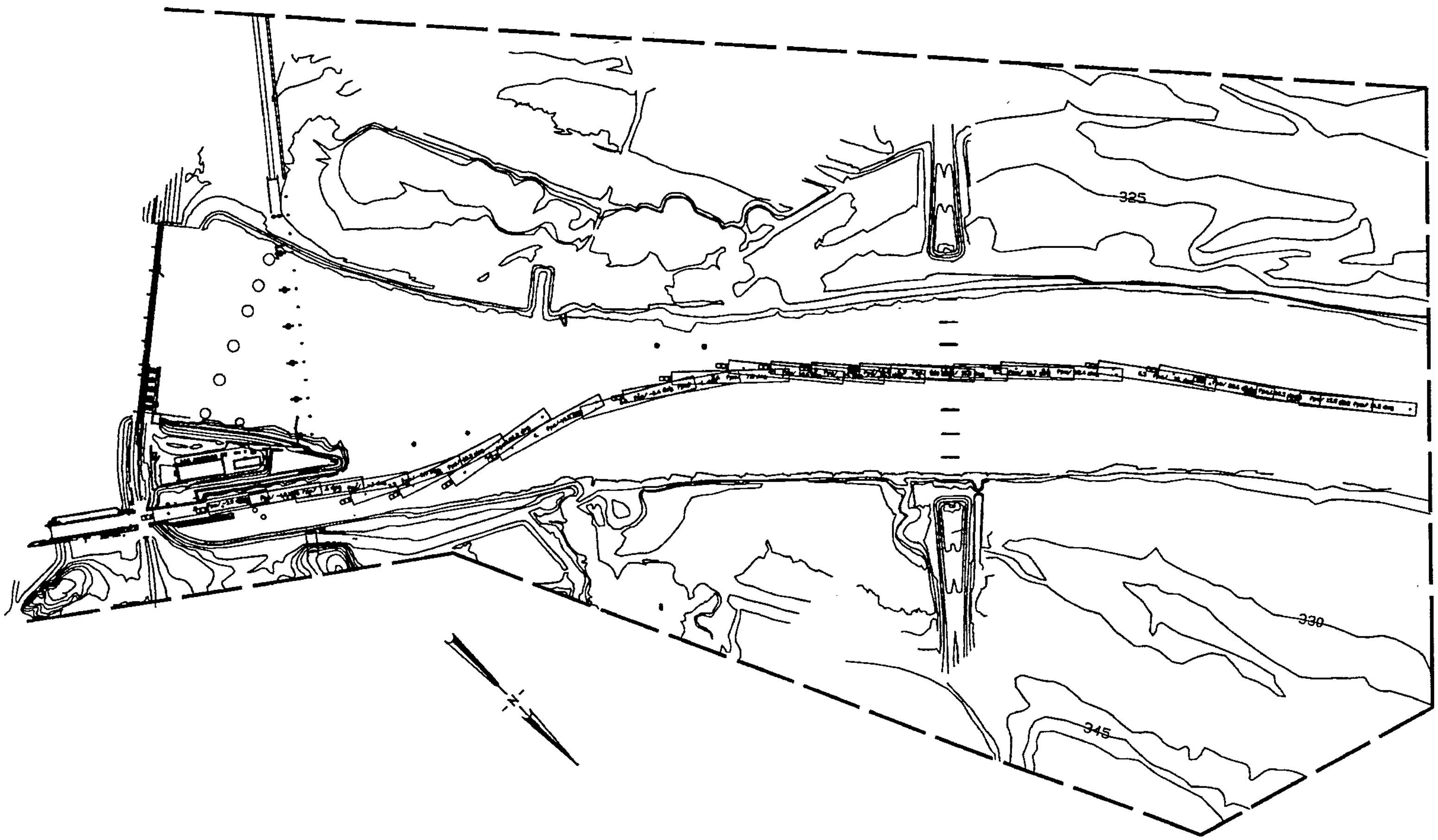
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND
CURRENT DIRECTIONS

COFFERDAM WALL SEGMENT 2

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT



LEGEND

NOTE : 15-BARGE TOW

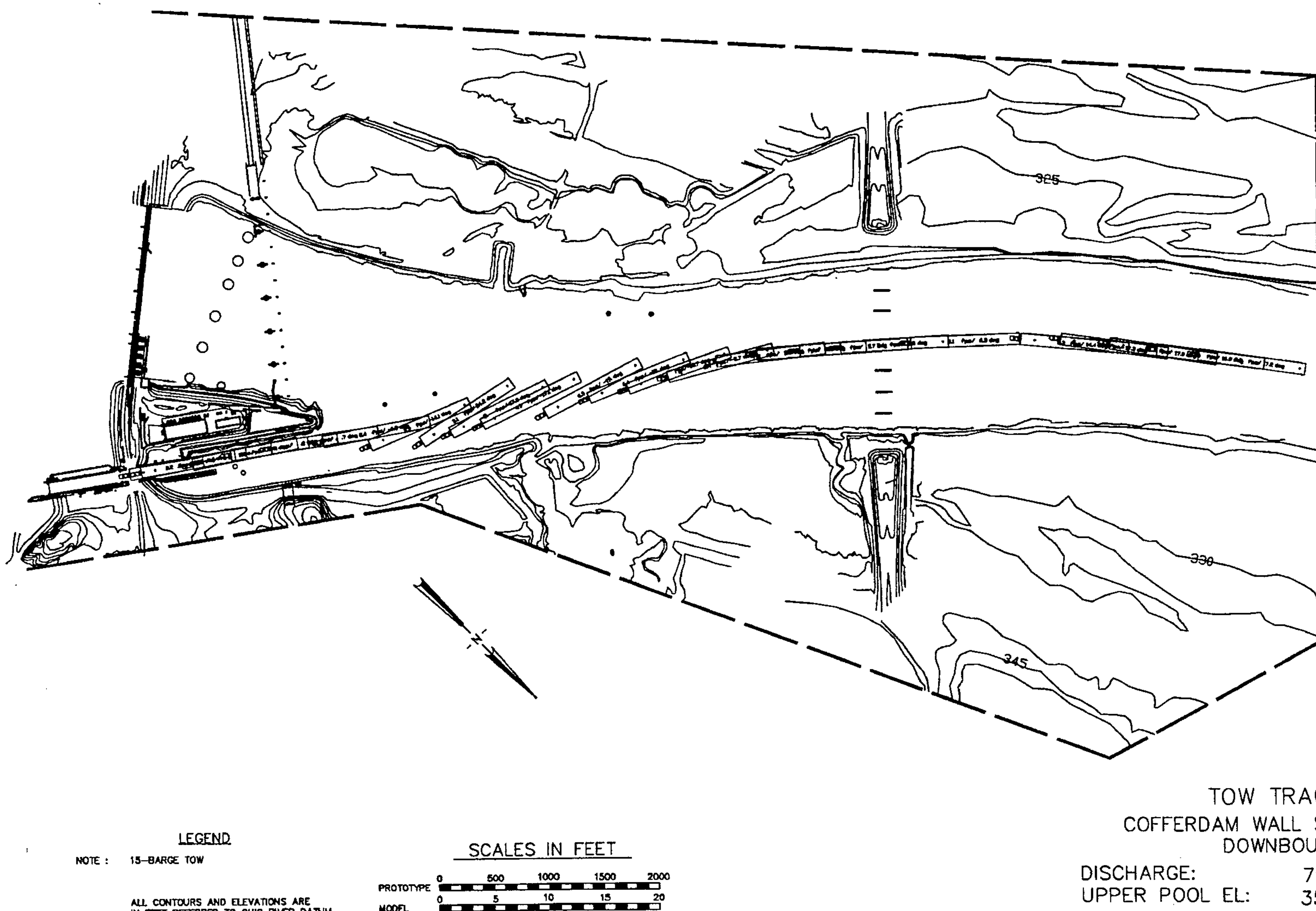
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 2
DOWNBOUND

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



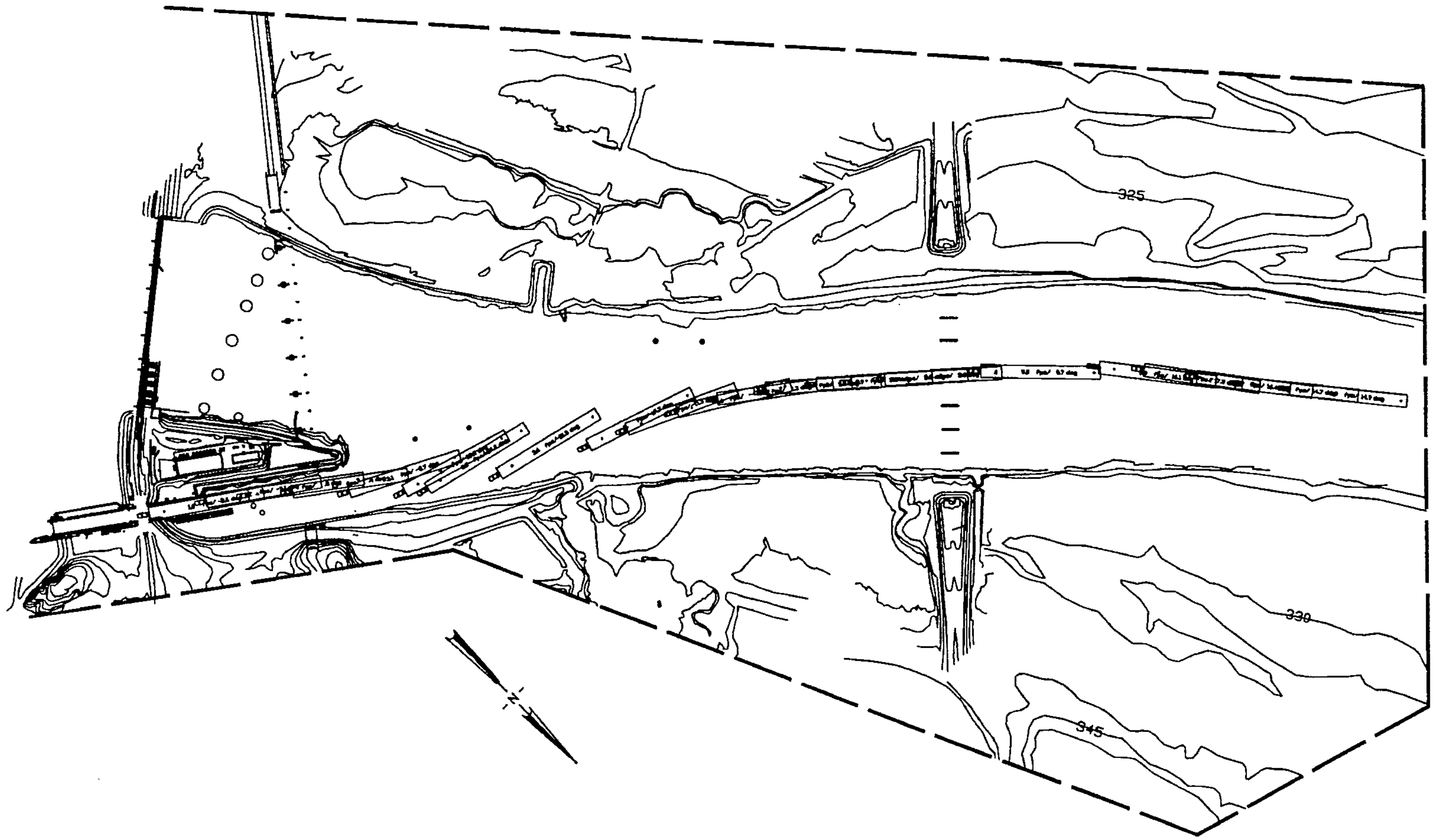
LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

TOW TRACKS
COFFERDAM WALL SEGMENT 2
DOWNBOUND

DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT



LEGEND

NOTE : 15-BARGE TOW

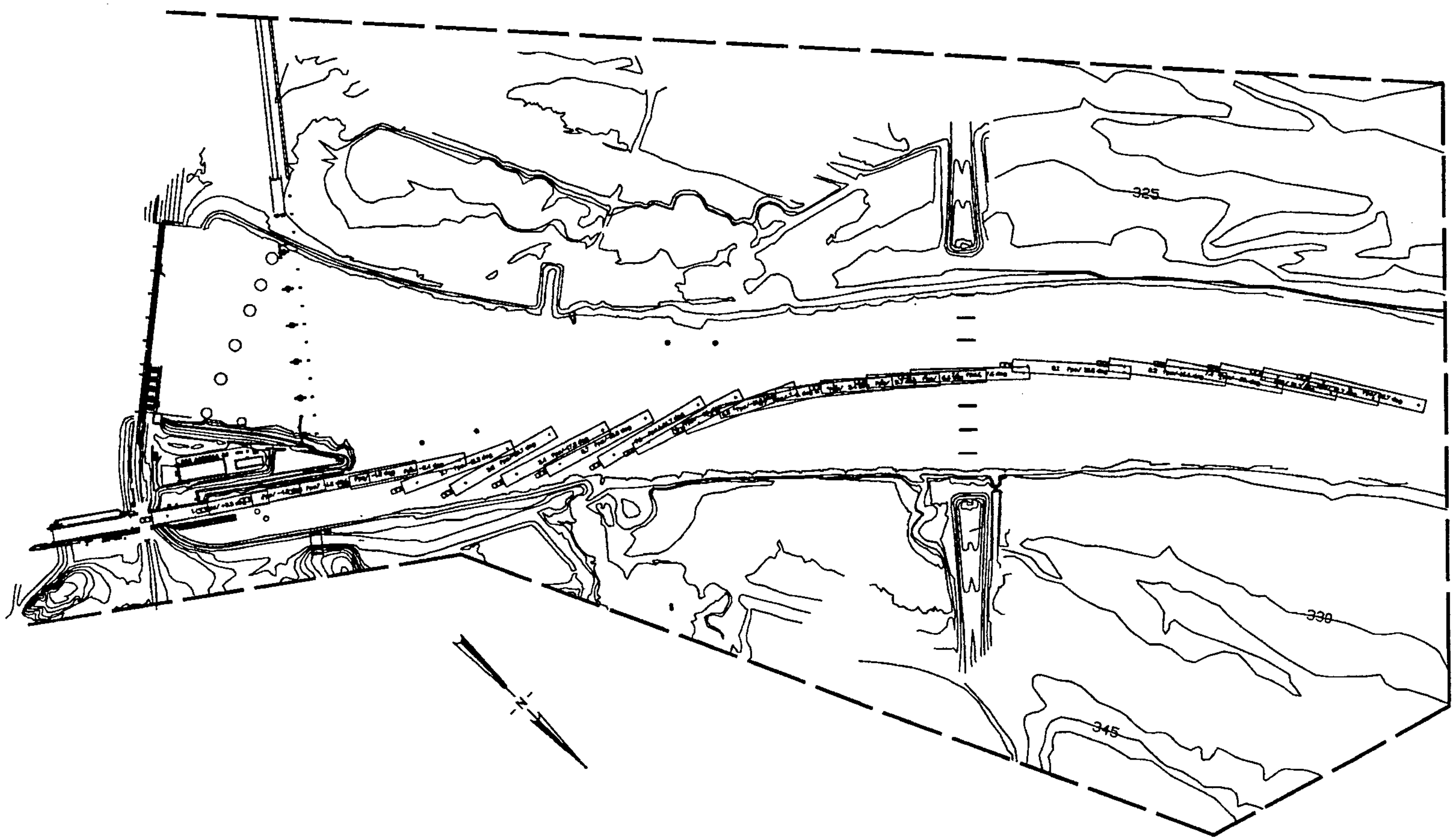
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 2
DOWNBOUND

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

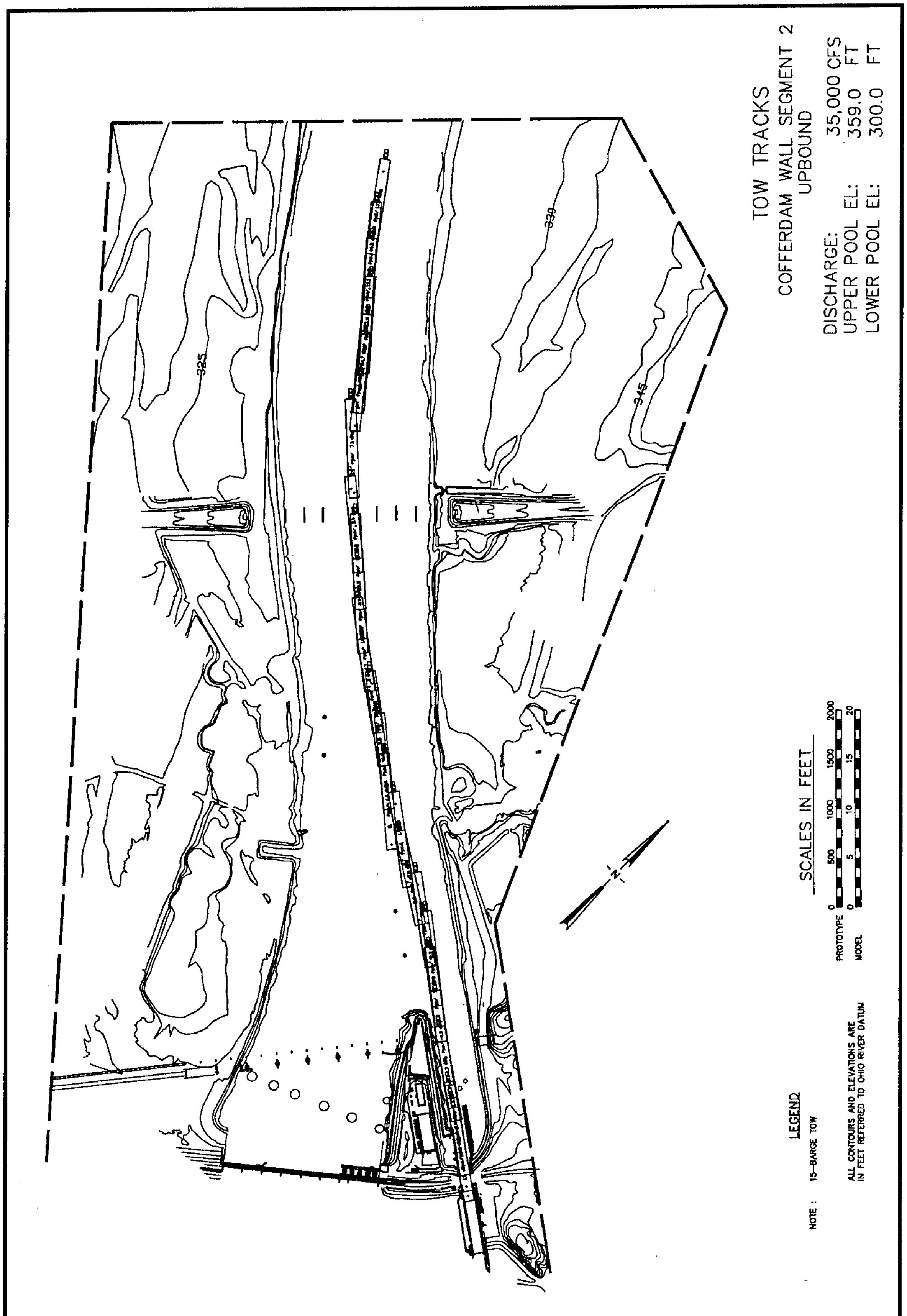
SCALES IN FEET

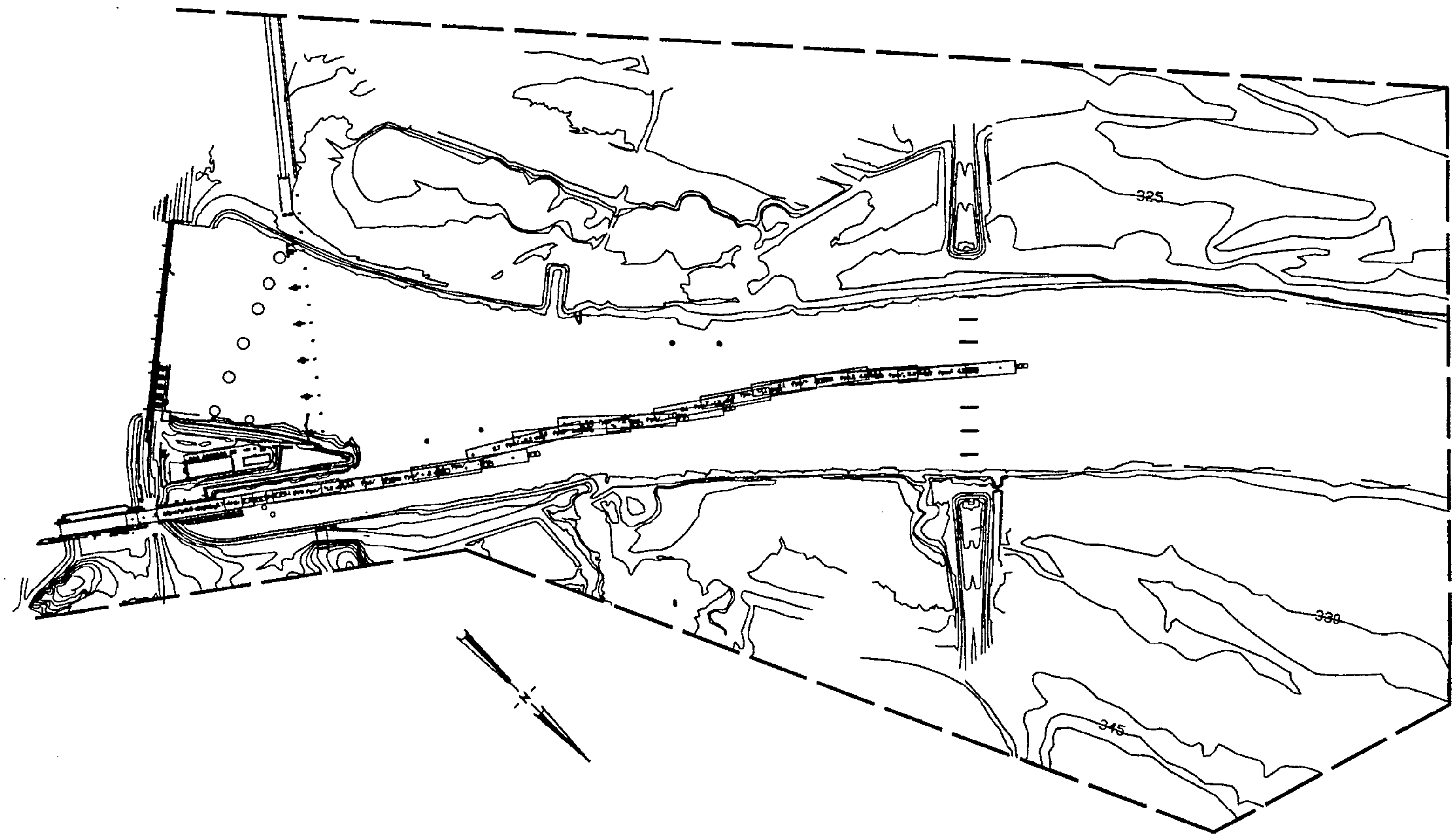
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 2
DOWNBOUND

DISCHARGE:	155,000	CFS
UPPER POOL EL:	359.0	FT
LOWER POOL EL:	316.0	FT


TOW TRACKS
COFFERDAM WALL SEGMENT 2
UPBOUND
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
15-BARGE TOW
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

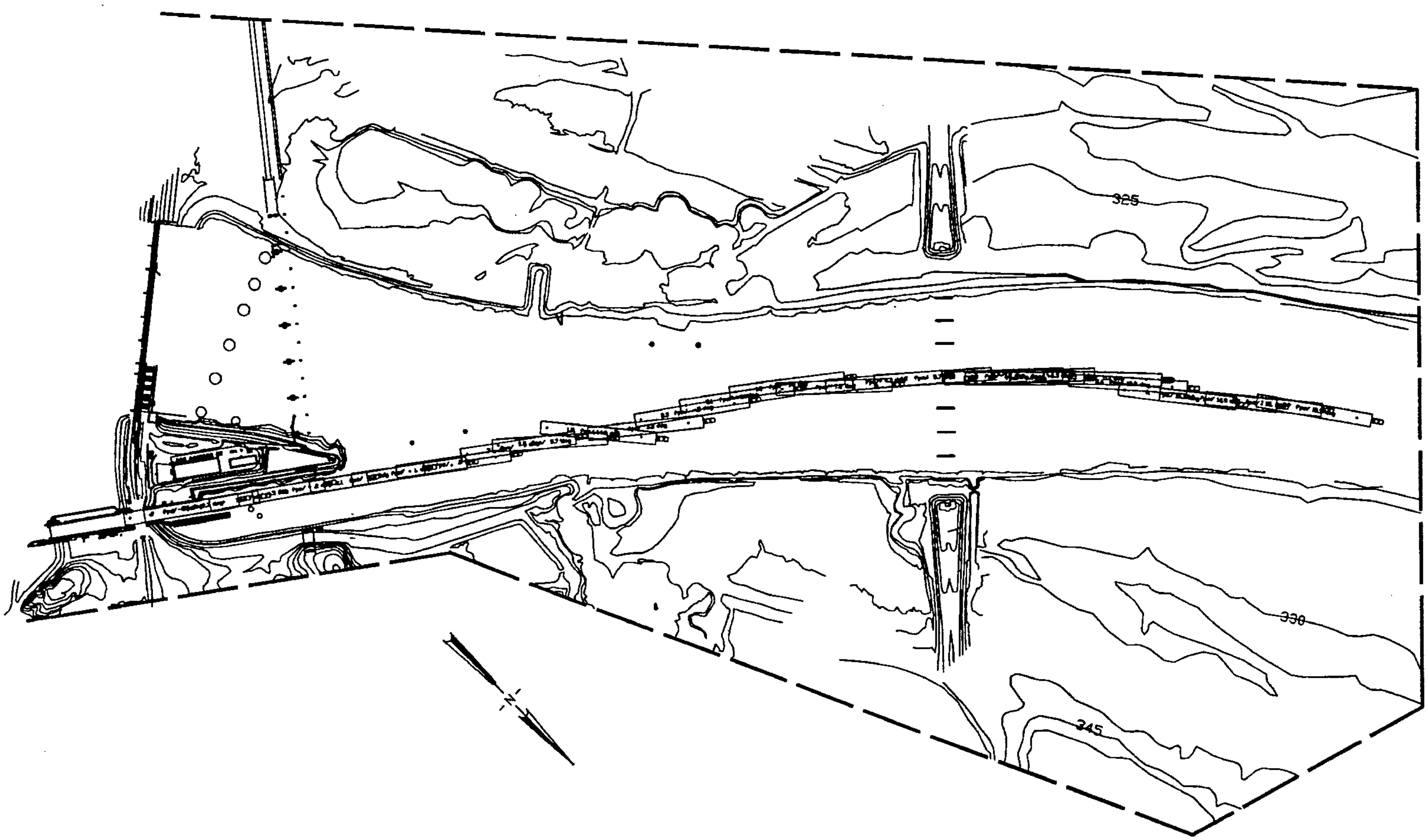
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
COFFERDAM WALL SEGMENT 2
UPBOUND WITH CAMELS

DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT



TOW TRACKS
COFFERDAM WALL SEGMENT 2
UPBOUND

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT

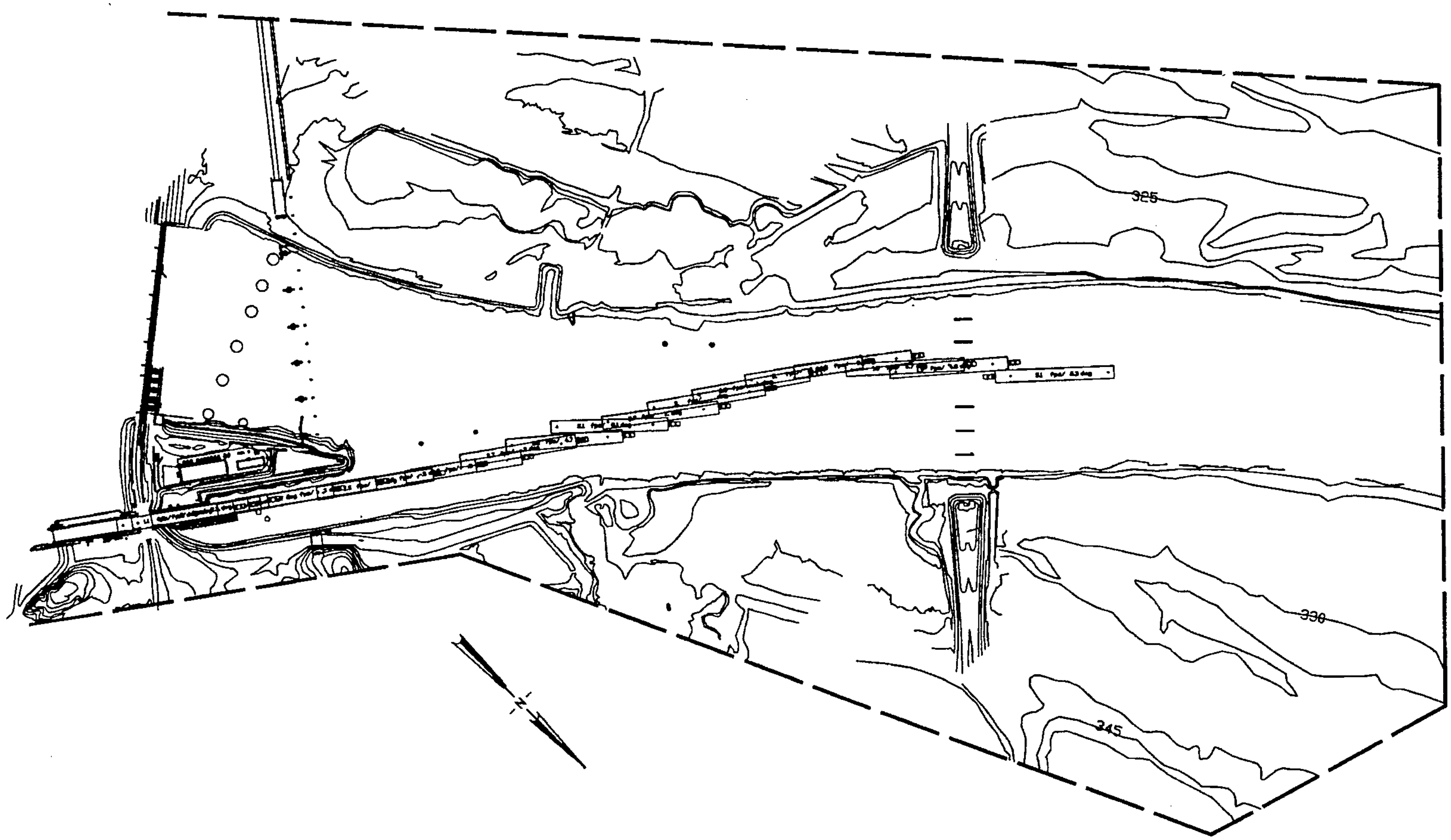
LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

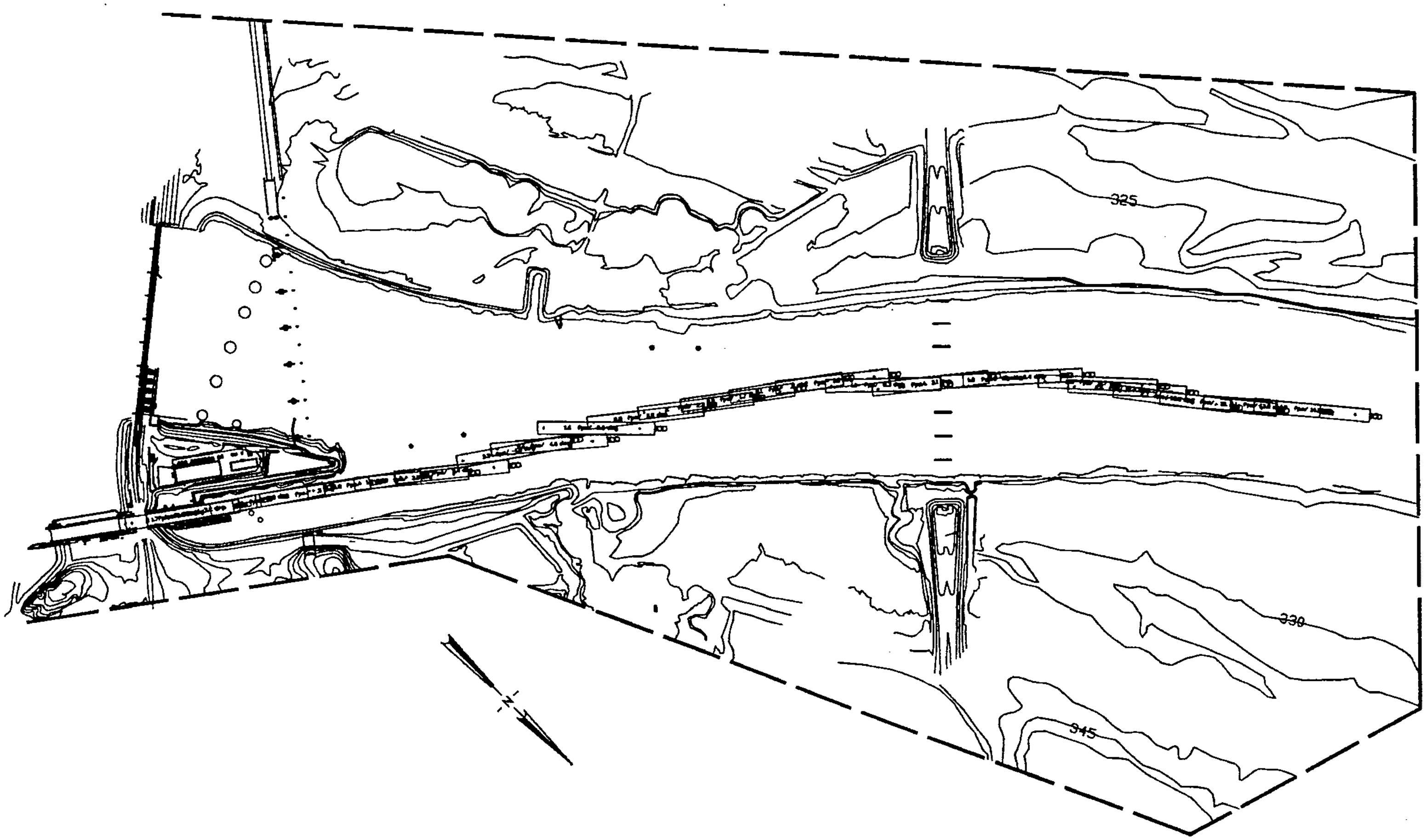
MODEL 0 5 10 15 20

TOW TRACKS

COFFERDAM WALL SEGMENT 2

UPBOUND WITH CAMELS

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



TOW TRACKS

COFFERDAM WALL SEGMENT 2
UPBOUND

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT

LEGEND

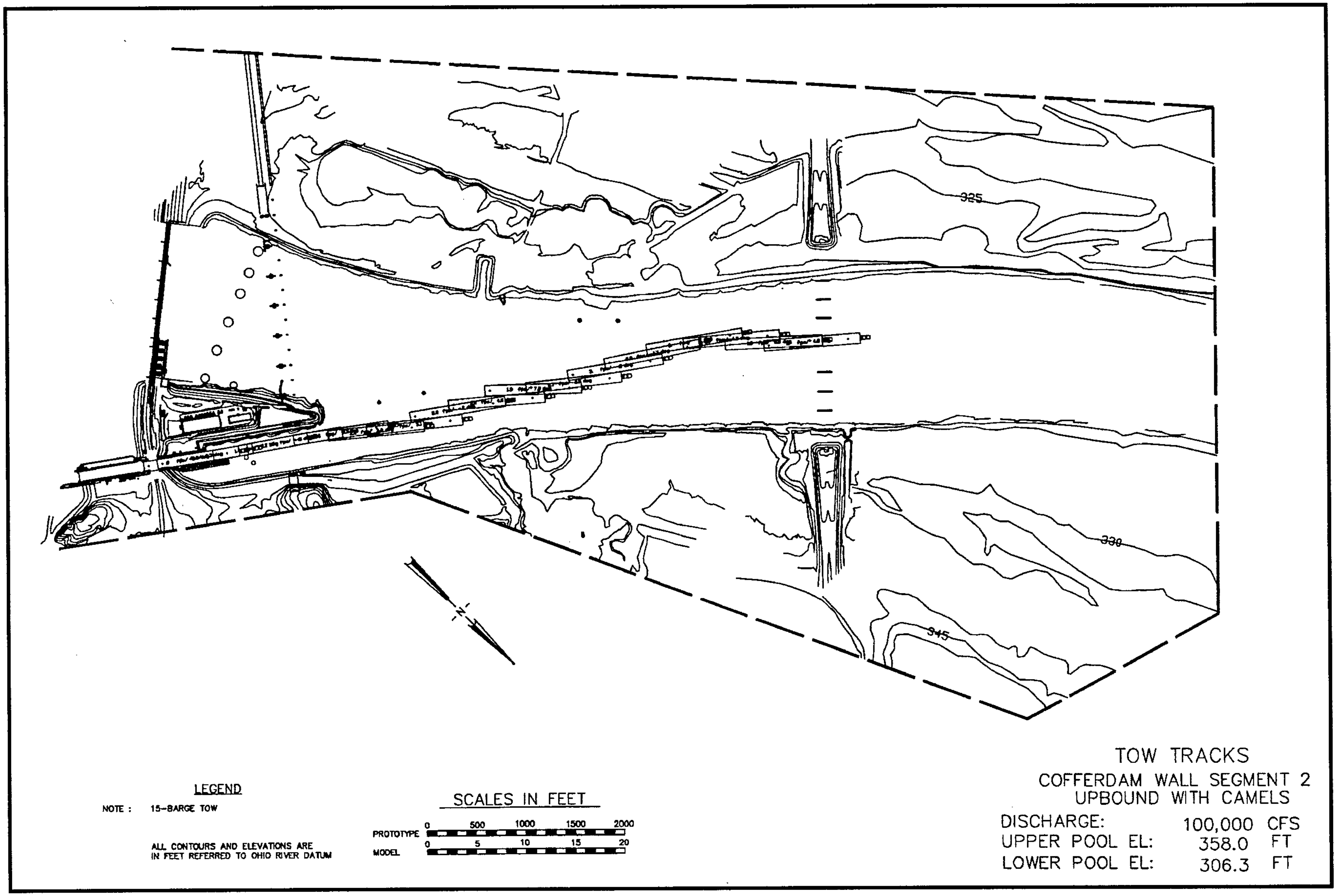
NOTE : 15-BARGE TOW

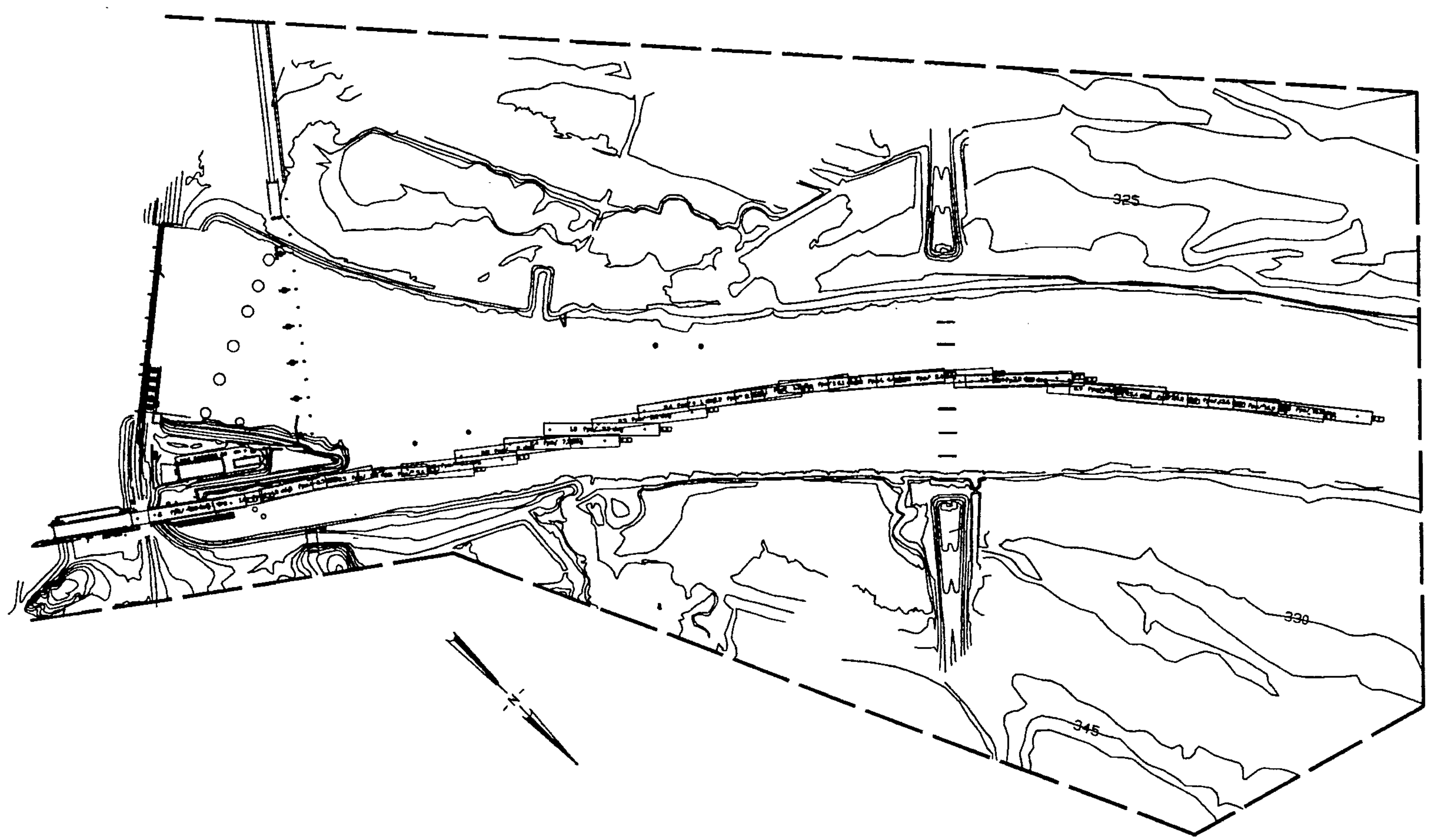
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
COFFERDAM WALL SEGMENT 2
UPBOUND WITH CAMELS
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



TOW TRACKS
COFFERDAM WALL SEGMENT 2
UPBOUND

DISCHARGE:	155,000	CFS
UPPER POOL EL:	359.0	FT
LOWER POOL EL:	316.0	FT

LEGEND

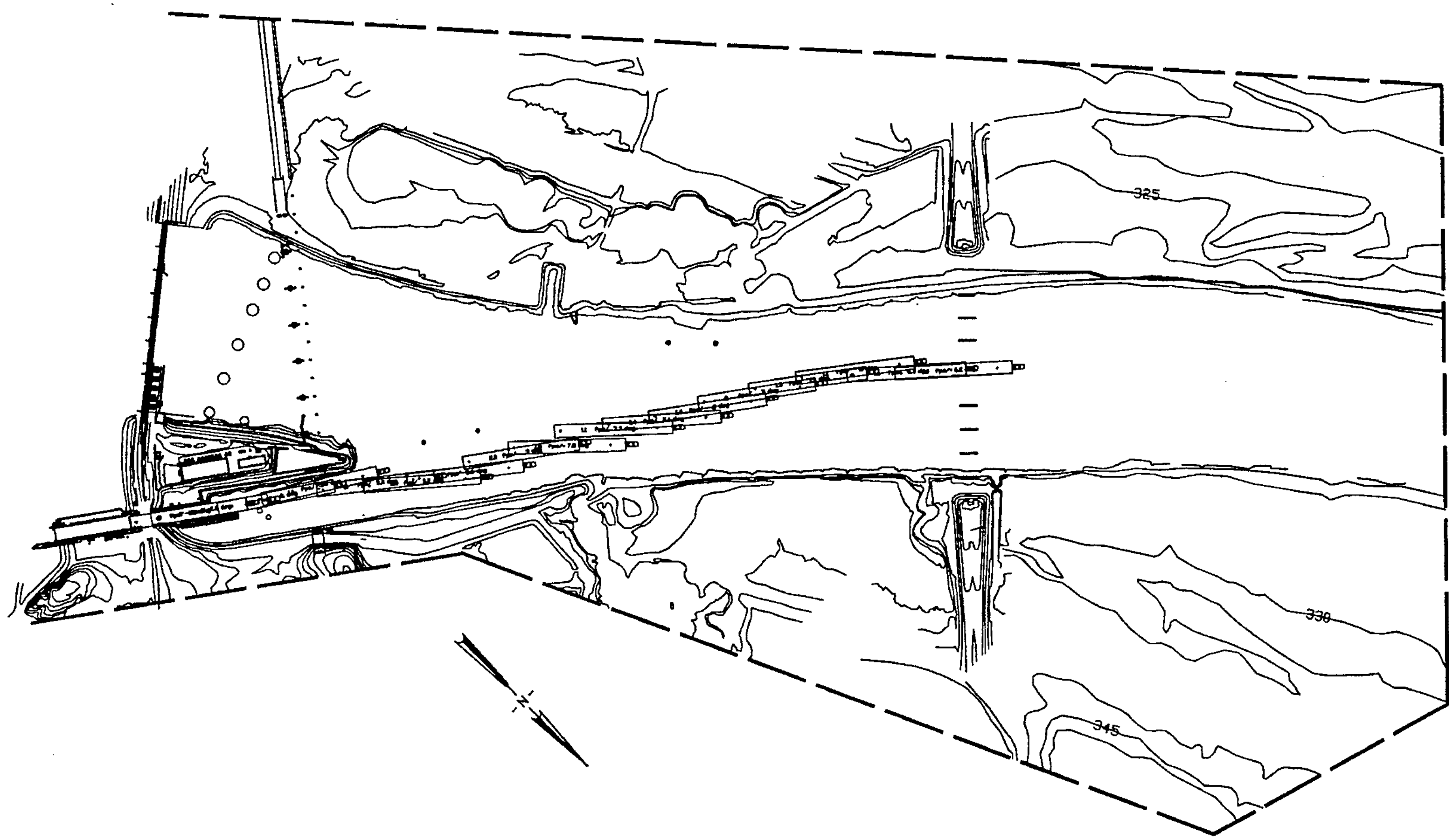
NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

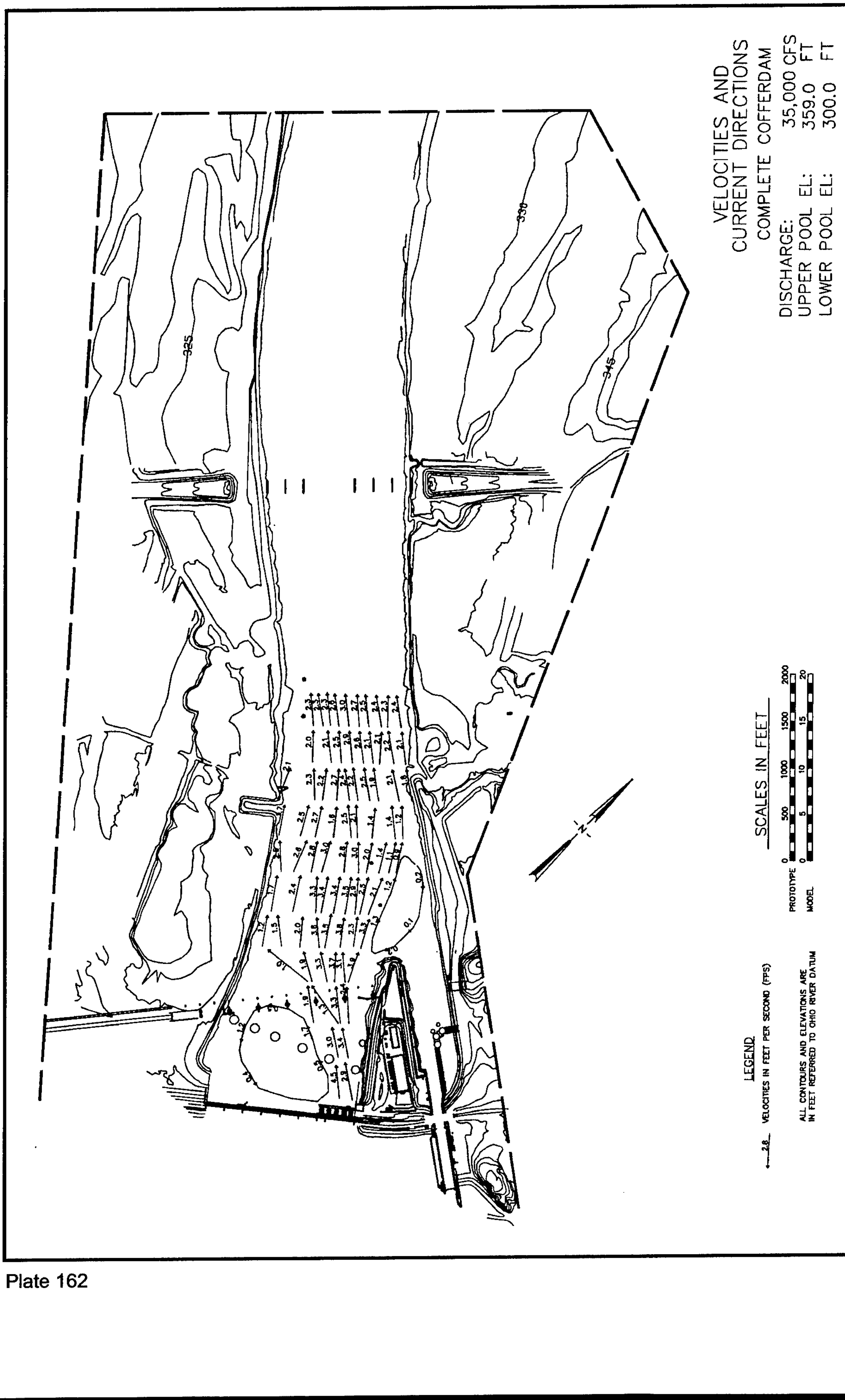
PROTOTYPE 0 500 1000 1500 2000

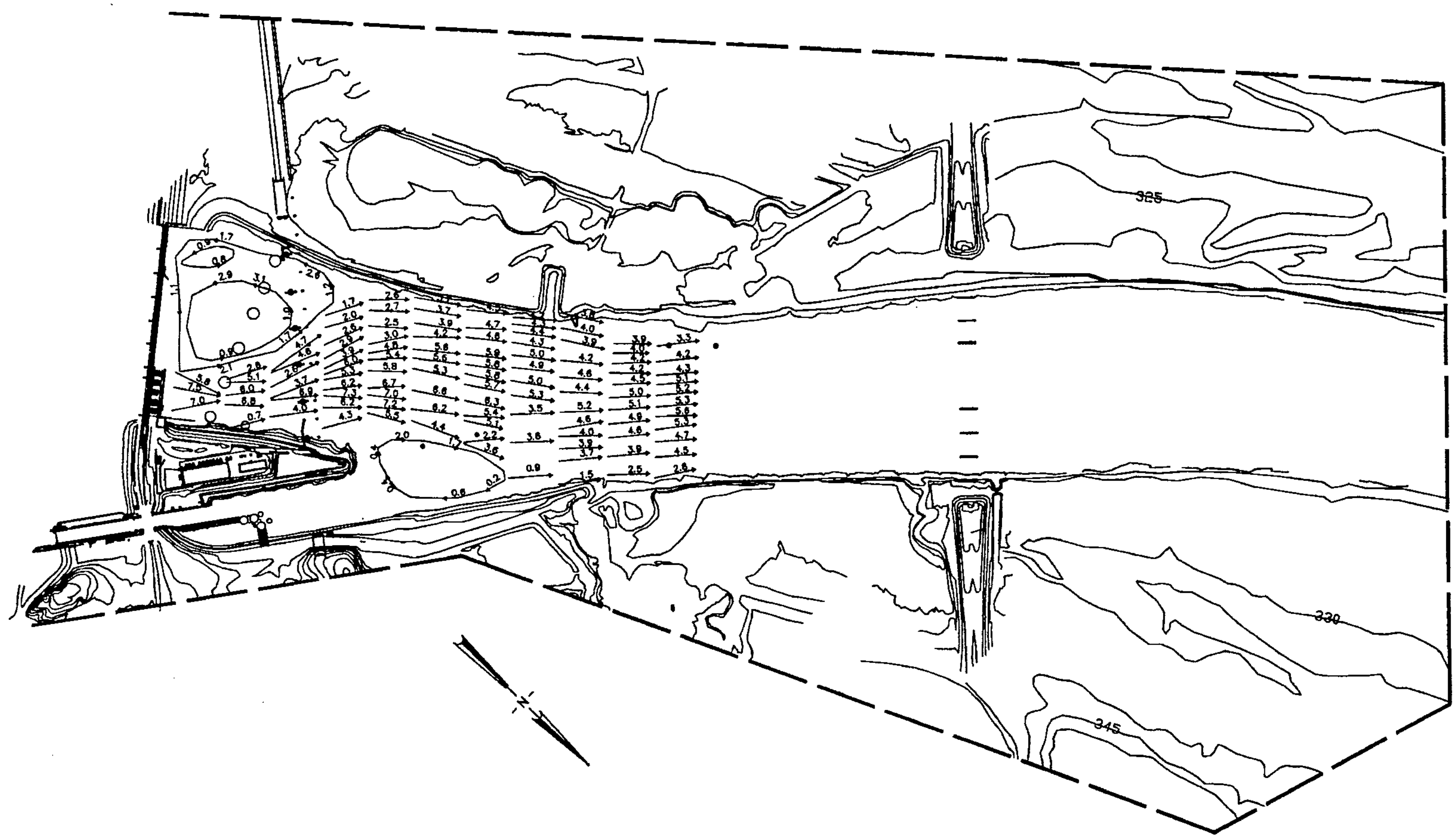
MODEL 0 5 10 15 20

TOW TRACKS

COFFERDAM WALL SEGMENT 2
UPBOUND WITH CAMELS

DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT


VELOCITIES AND
CURRENT DIRECTIONS
COMPLETE COFFERDAM
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
2.8 VELOCITIES IN FEET PER SECOND (FPS)
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

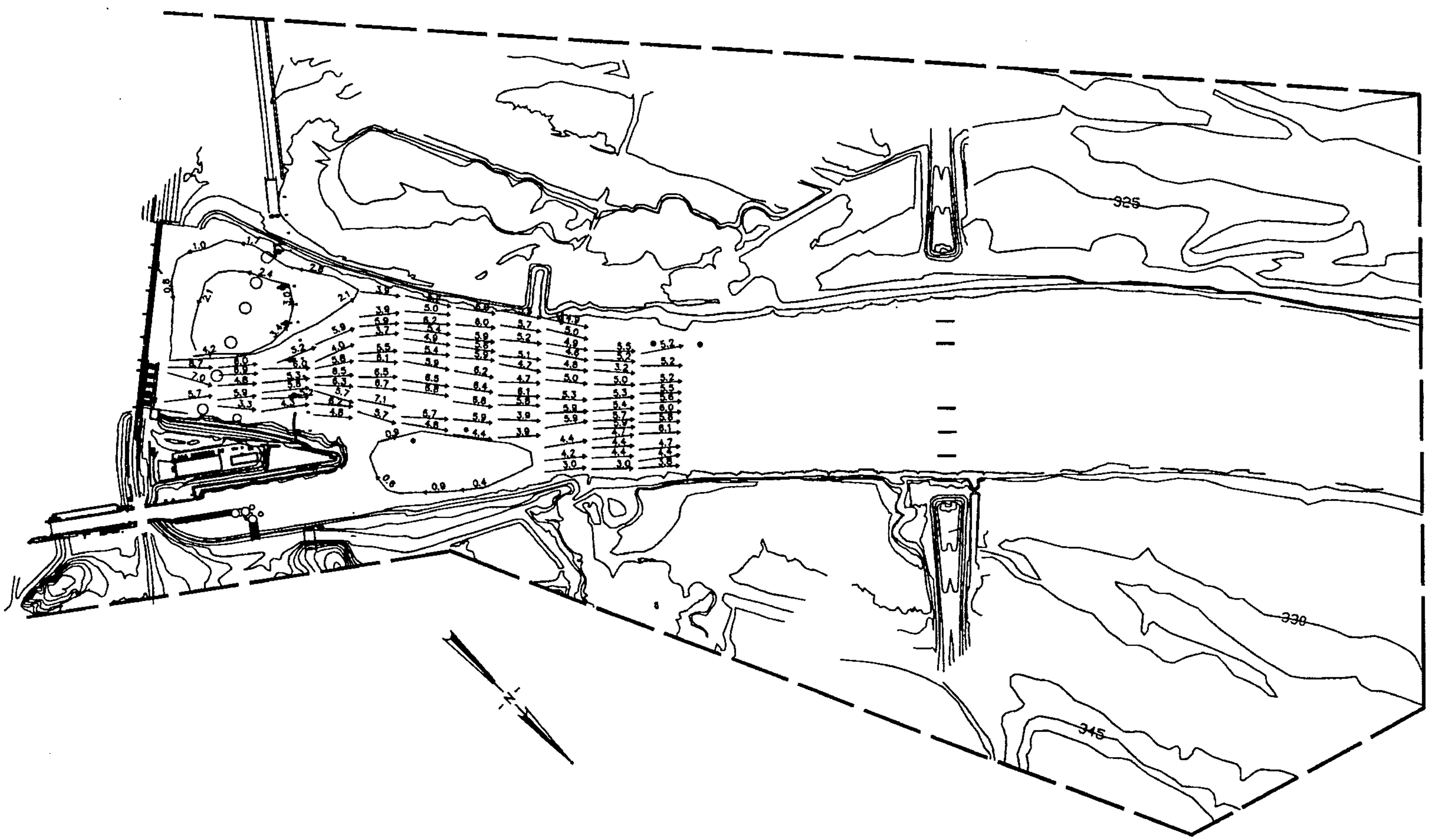
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

COMPLETE COFFERDAM

DISCHARGE:	79,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	303.6 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

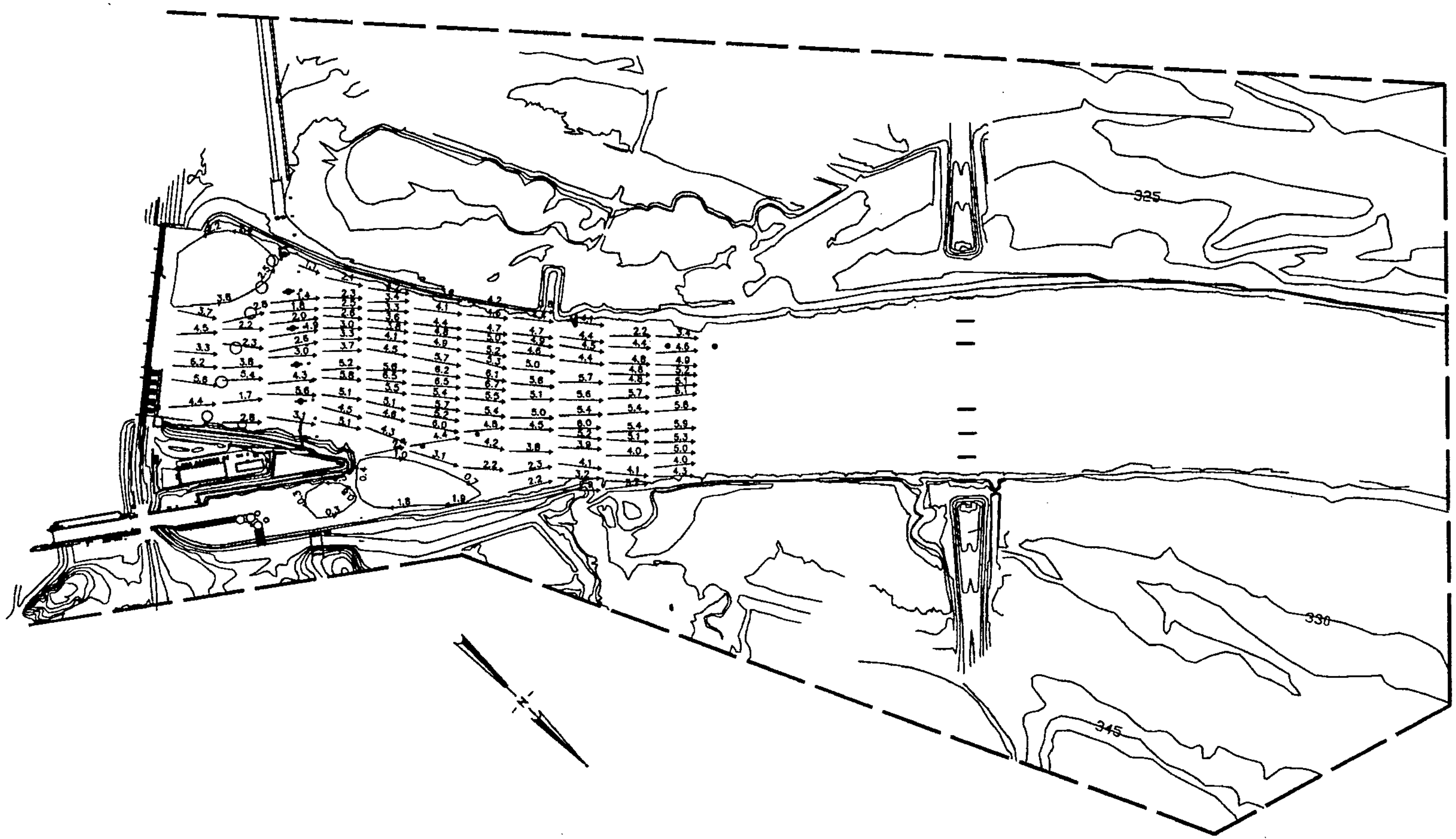
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

COMPLETE COFFERDAM

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

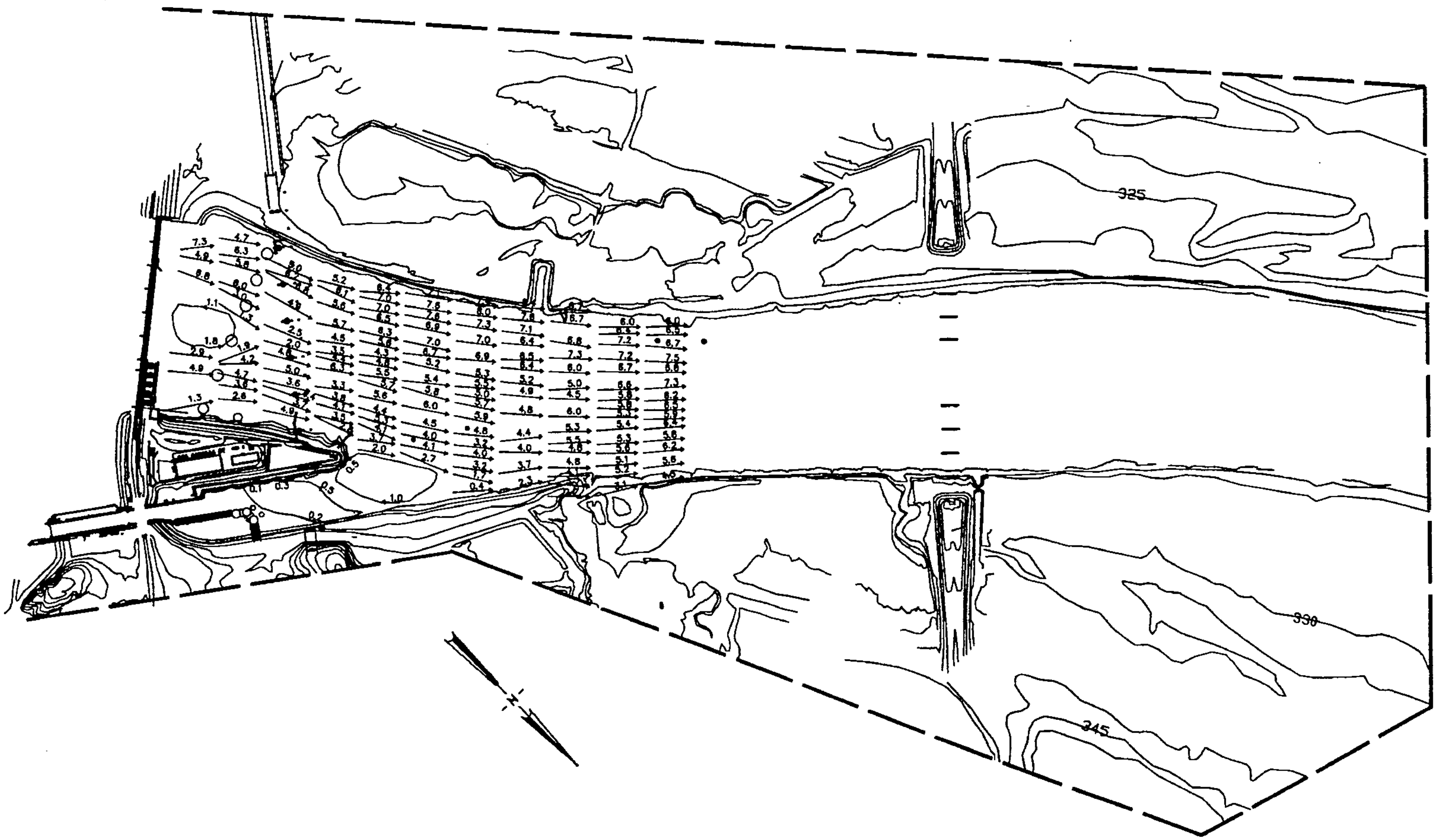
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

COMPLETE COFFERDAM

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

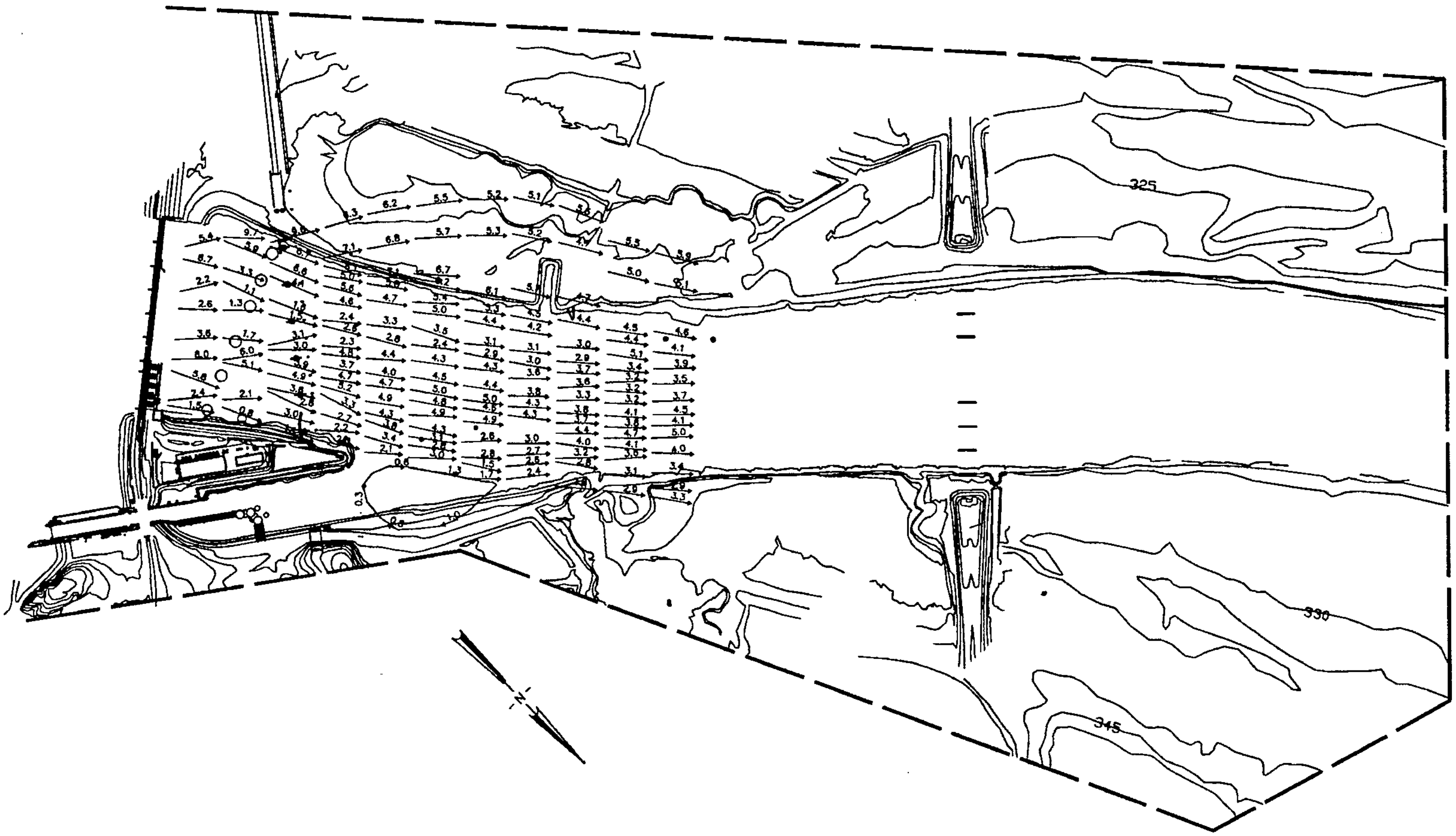
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

COMPLETE COFFERDAM

DISCHARGE:	300,000 CFS
UPPER POOL EL:	362.5 FT
LOWER POOL EL:	328.0 FT



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

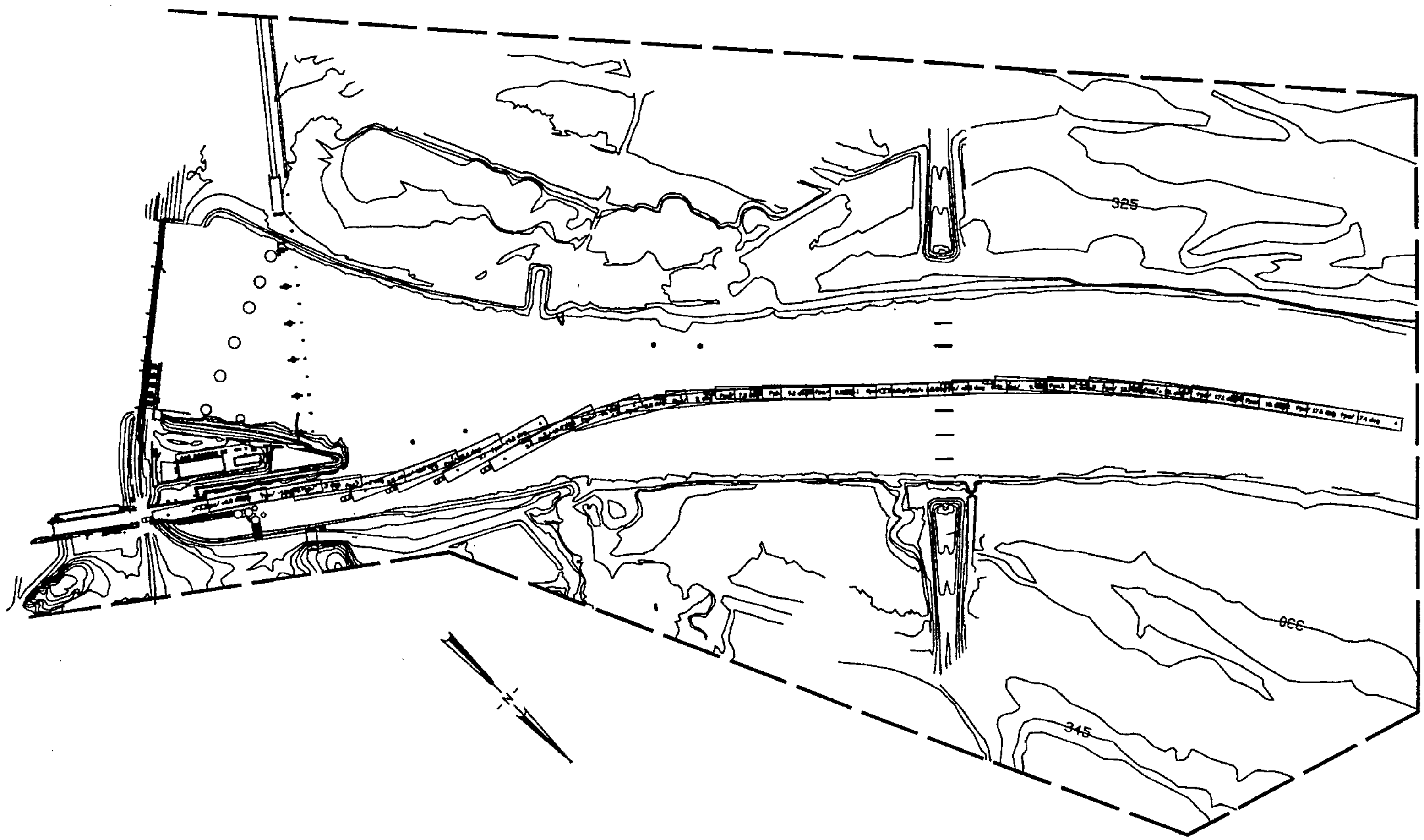
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

COMPLETE COFFERDAM

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

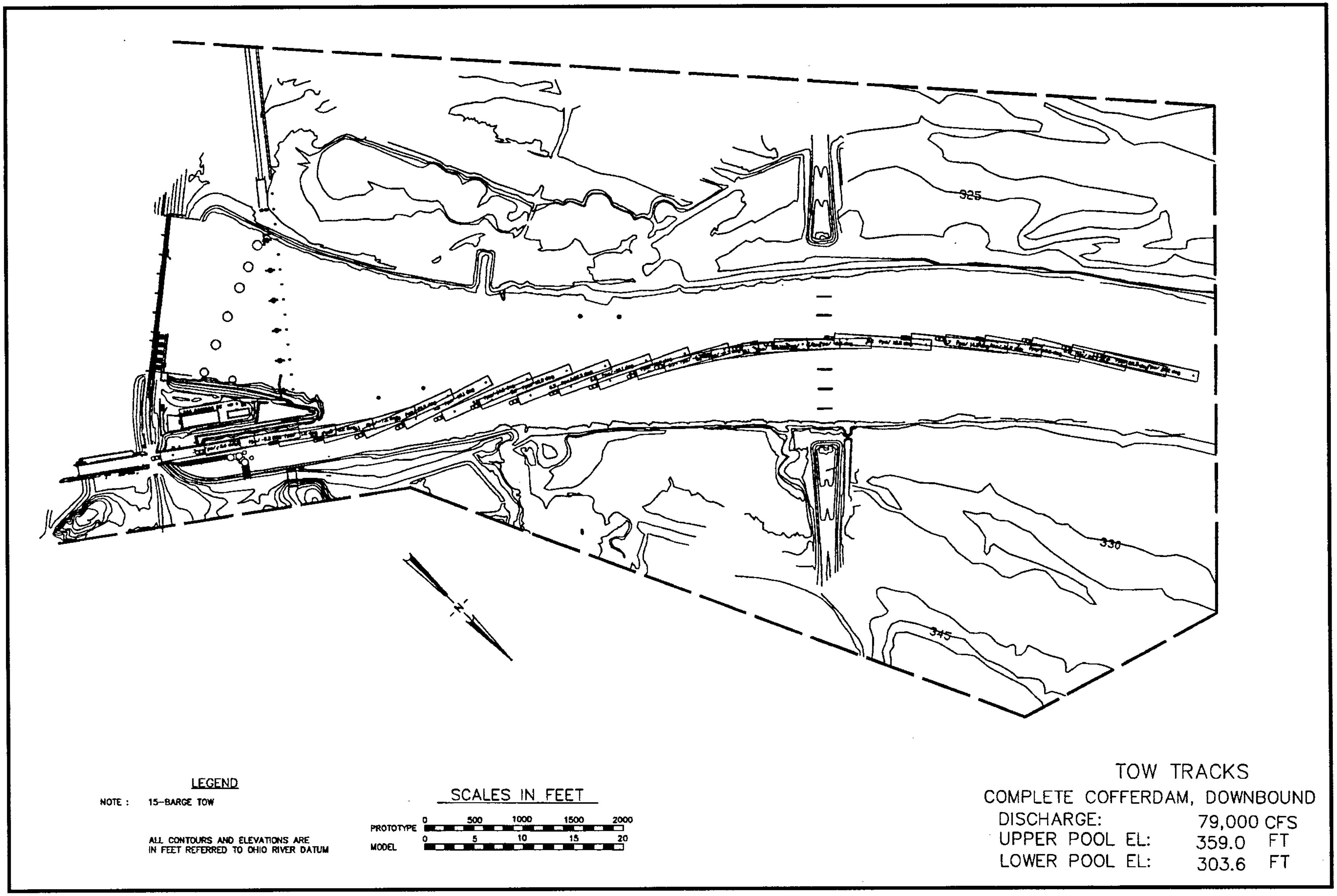
PROTOTYPE 0 500 1000 1500 2000

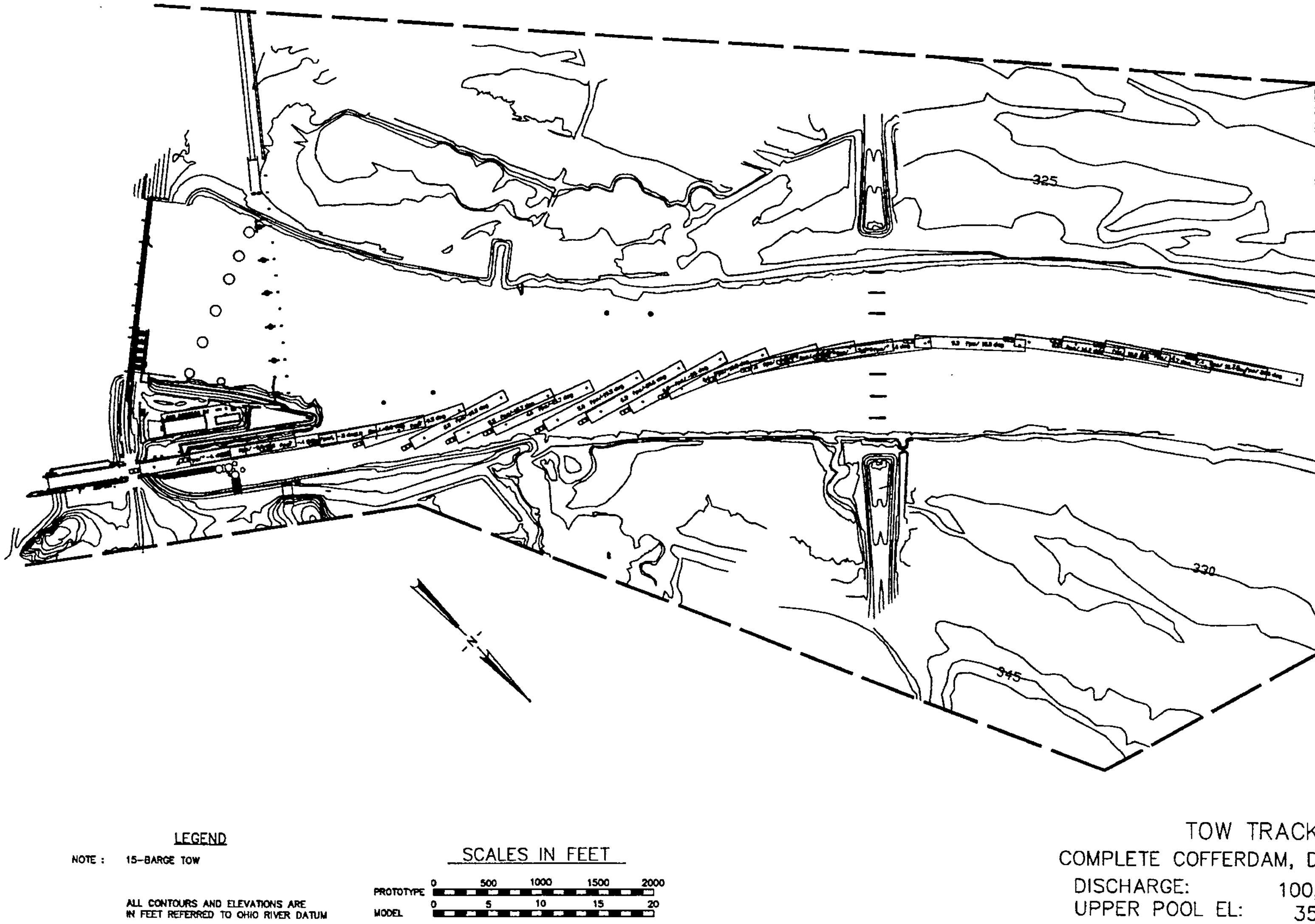
MODEL 0 5 10 15 20

TOW TRACKS

COMPLETE COFFERDAM, DOWNBOUND

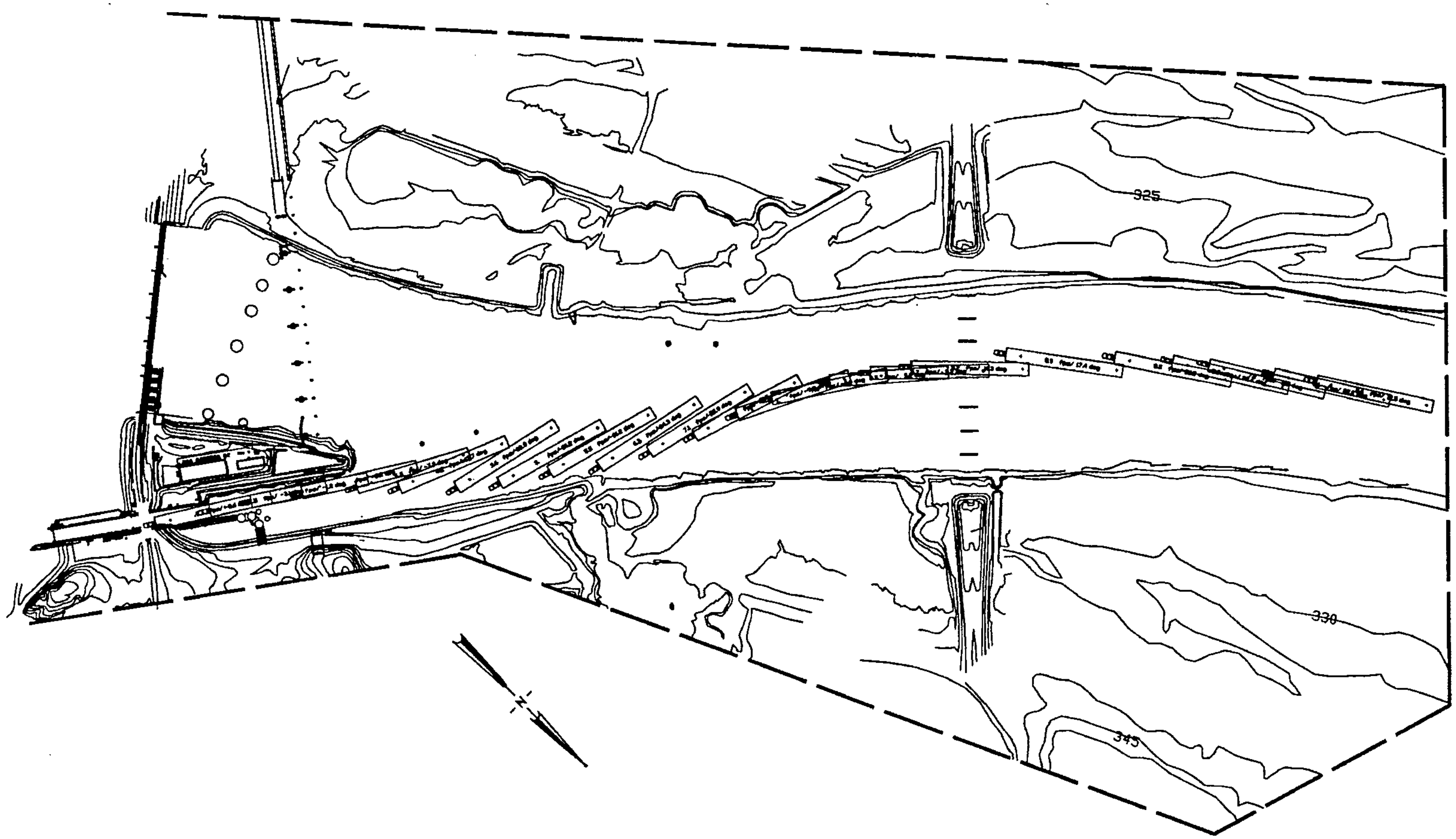
DISCHARGE:	35,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	300.0 FT


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
COMPLETE COFFERDAM, DOWNBOUND
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT



TOW TRACKS
COMPLETE COFFERDAM, DOWNBOUND

DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15-BARGE TOW

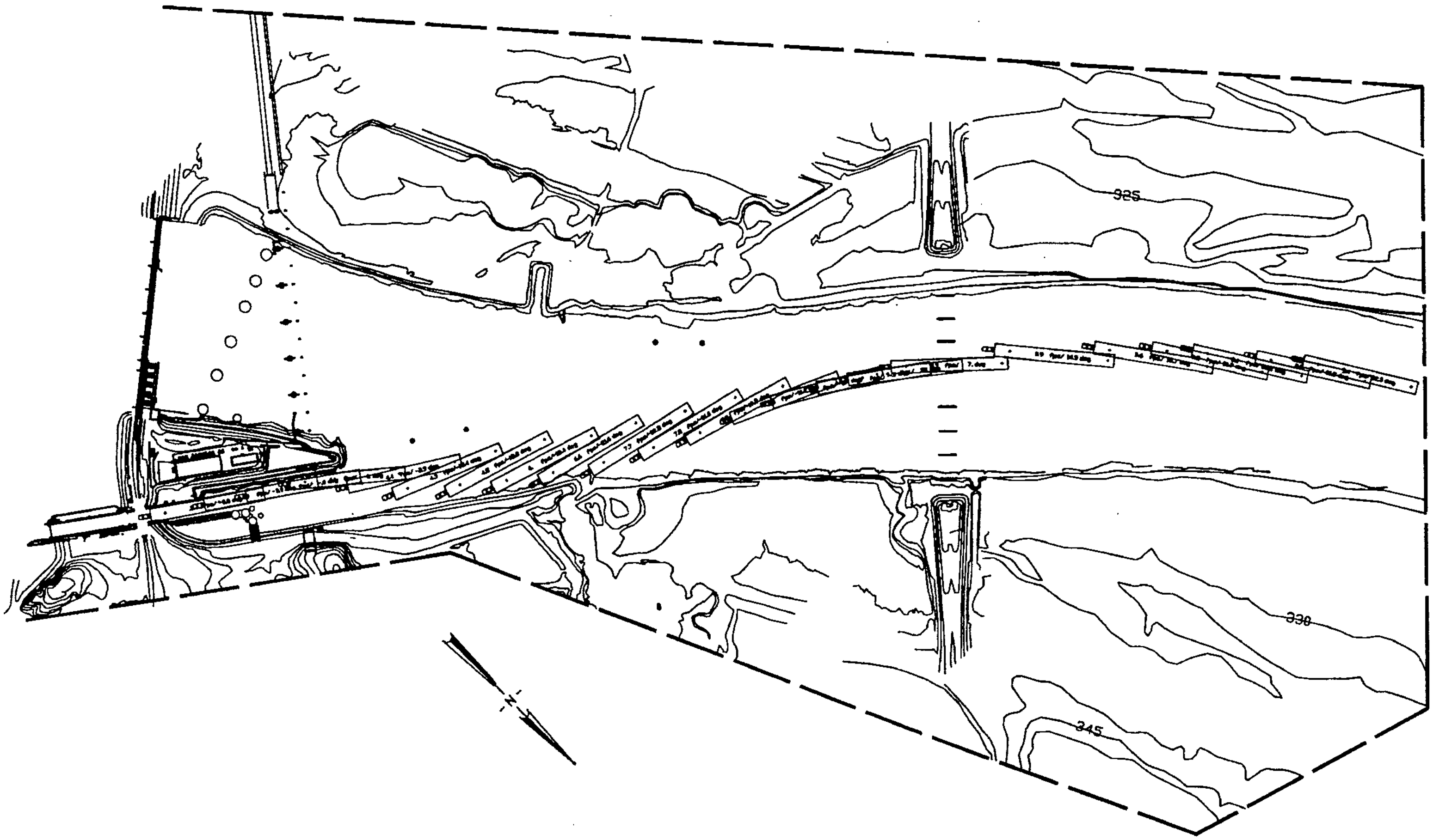
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
COMPLETE COFFERDAM, DOWNBOUND

DISCHARGE:	155,000 CFS
UPPER POOL EL:	359.0 FT
LOWER POOL EL:	316.0 FT



LEGEND

NOTE : 15-BARGE TOW

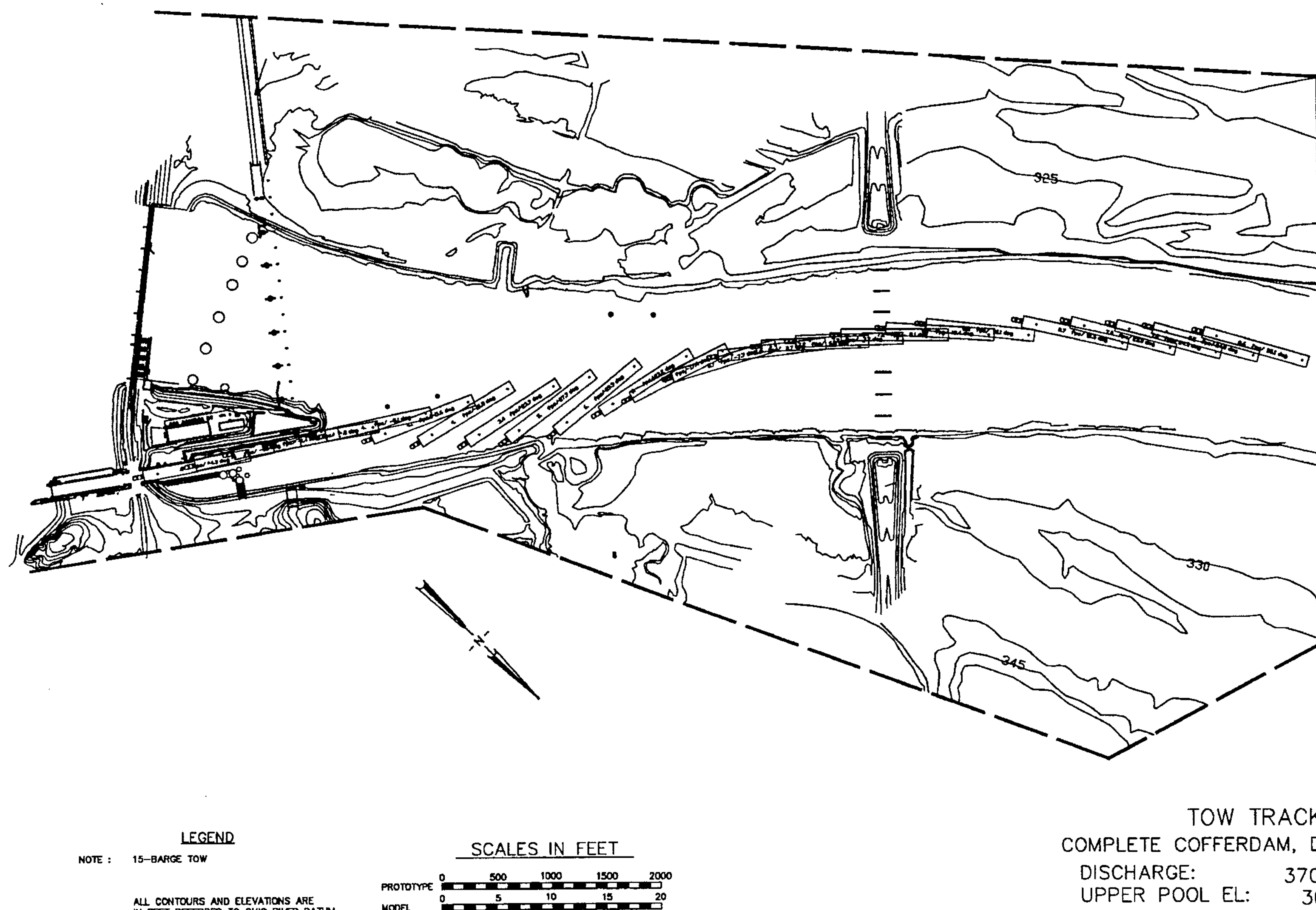
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

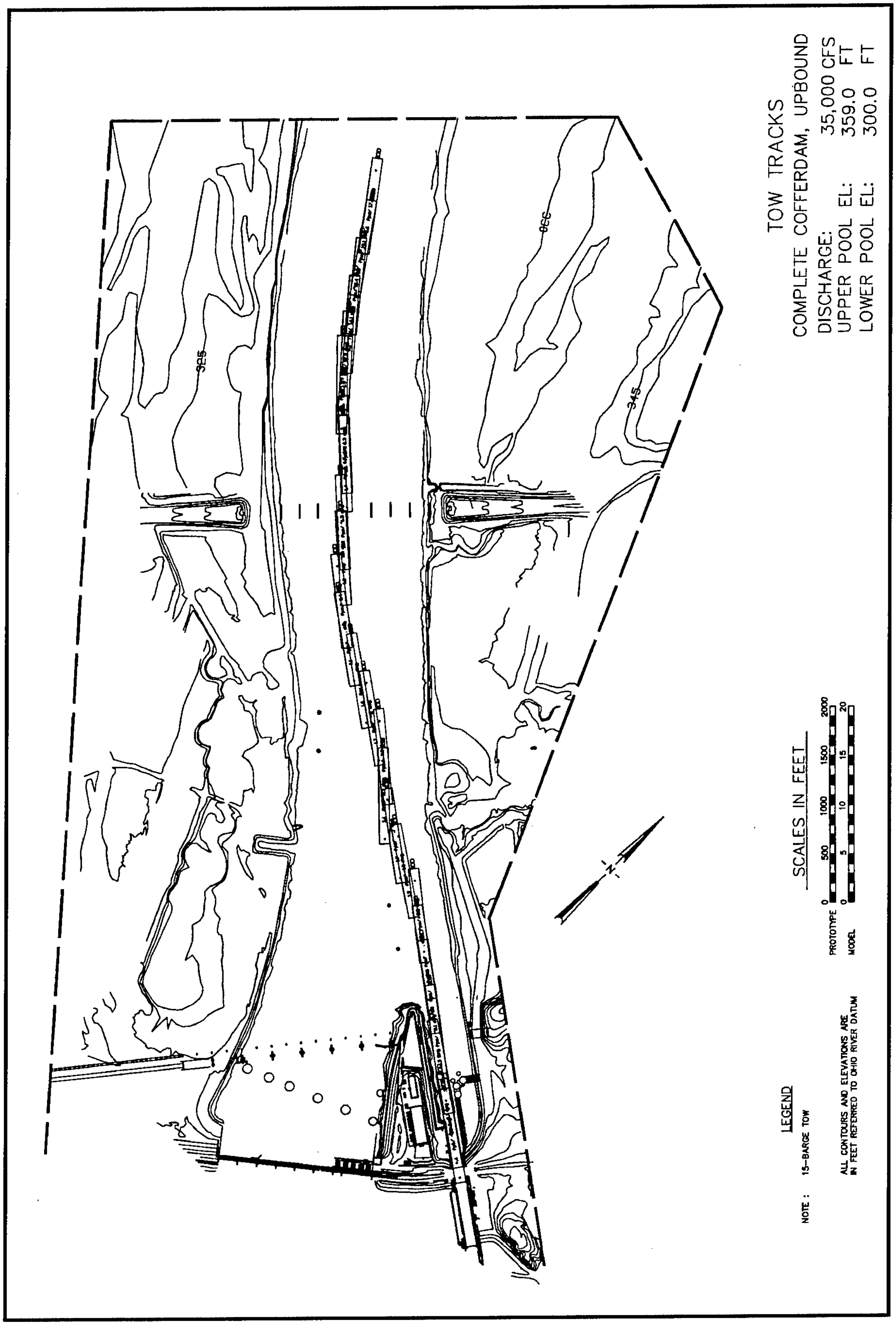
TOW TRACKS
COMPLETE COFFERDAM, DOWNBOUND

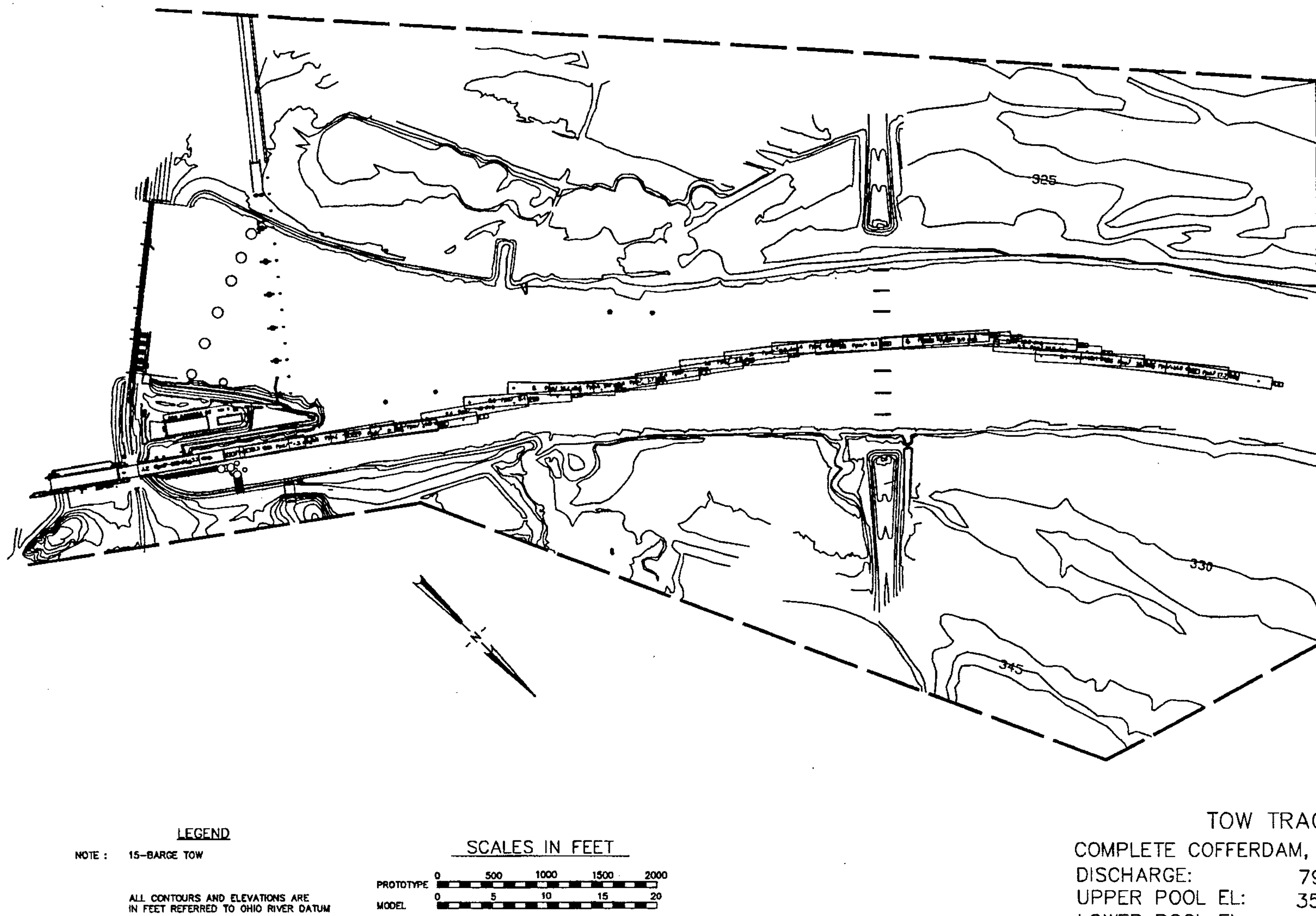
DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



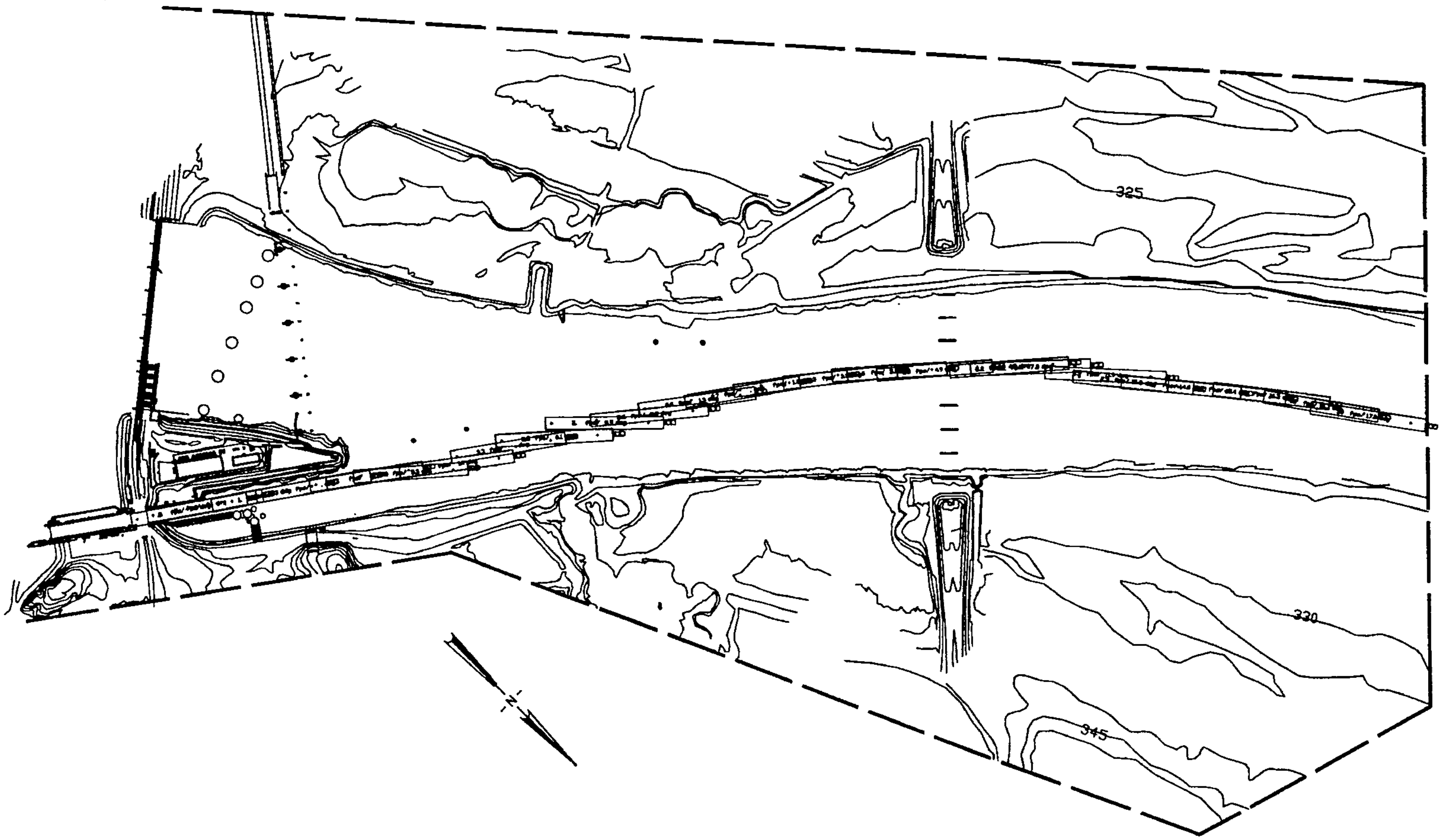
TOW TRACKS
COMPLETE COFFERDAM, DOWNBOUND

DISCHARGE:	370,000 CFS
UPPER POOL EL:	368.3 FT
LOWER POOL EL:	344.0 FT


TOW TRACKS
COMPLETE COFFERDAM, UPBOUND
DISCHARGE: 35,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 300.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE: 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
330
345
N



TOW TRACKS
COMPLETE COFFERDAM, UPBOUND
DISCHARGE: 79,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 303.6 FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

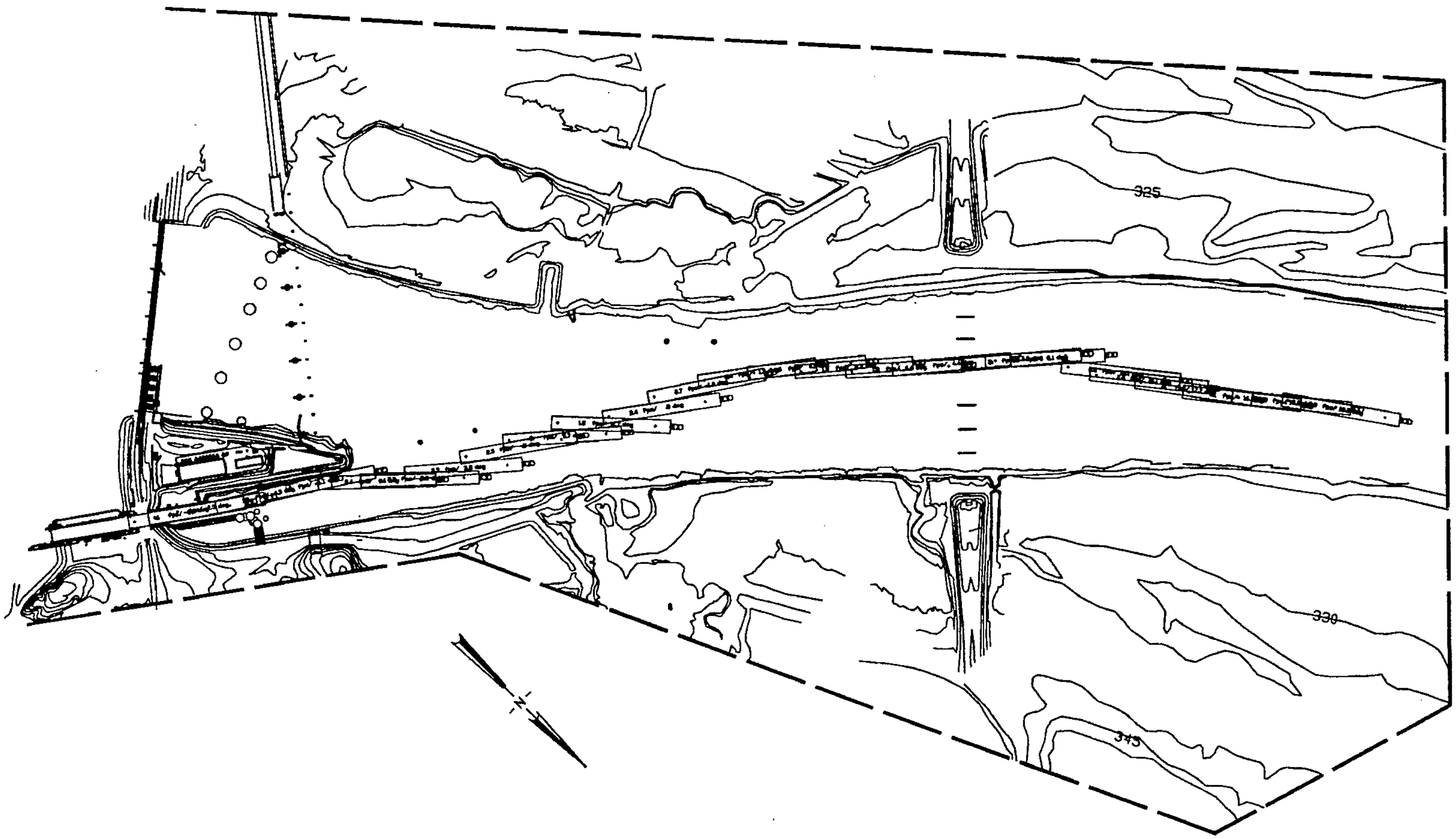
TOW TRACKS

COMPLETE COFFERDAM, UPBOUND

DISCHARGE: 100,000 CFS

UPPER POOL EL: 358.0 FT

LOWER POOL EL: 306.3 FT



LEGEND

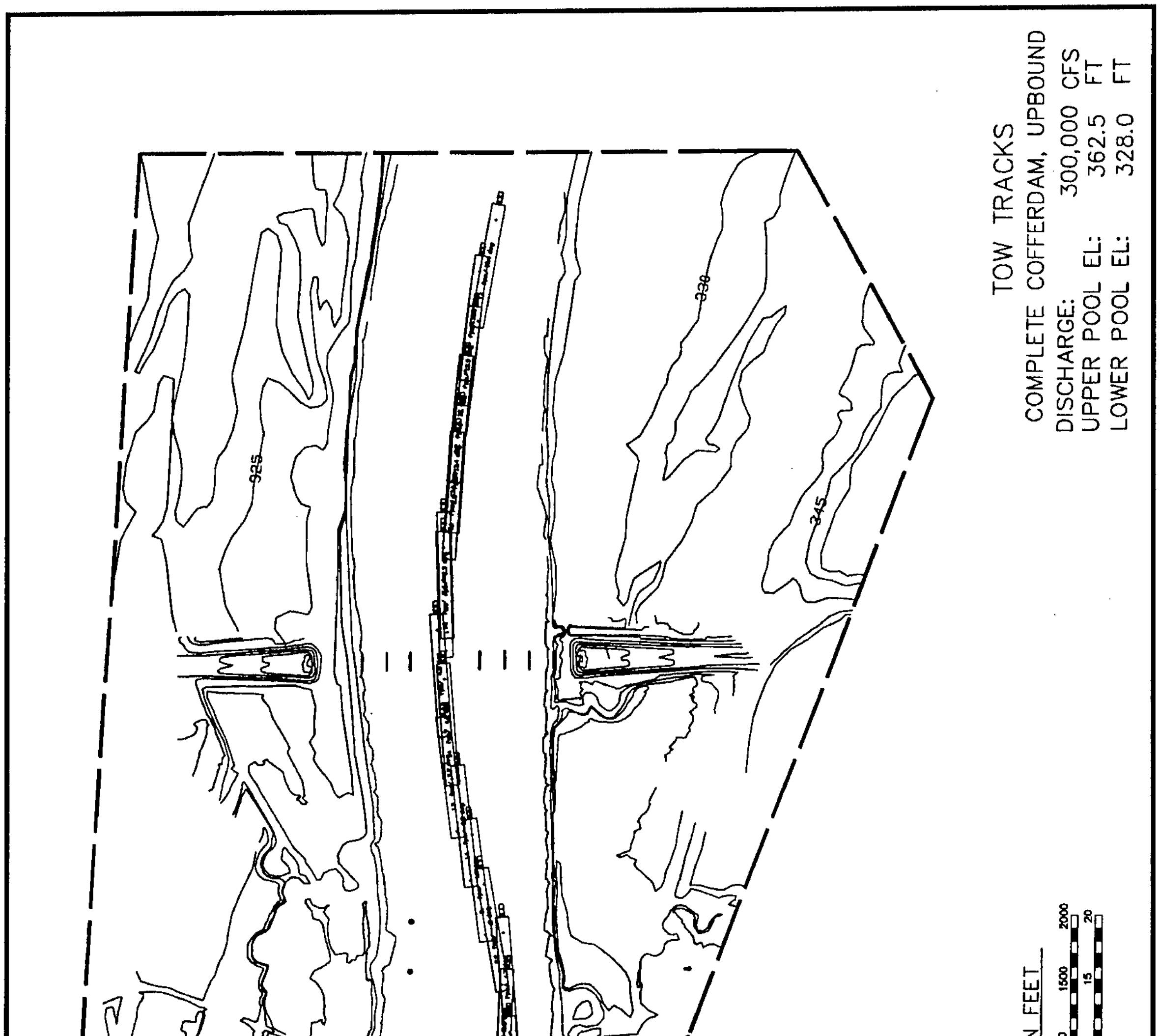
NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

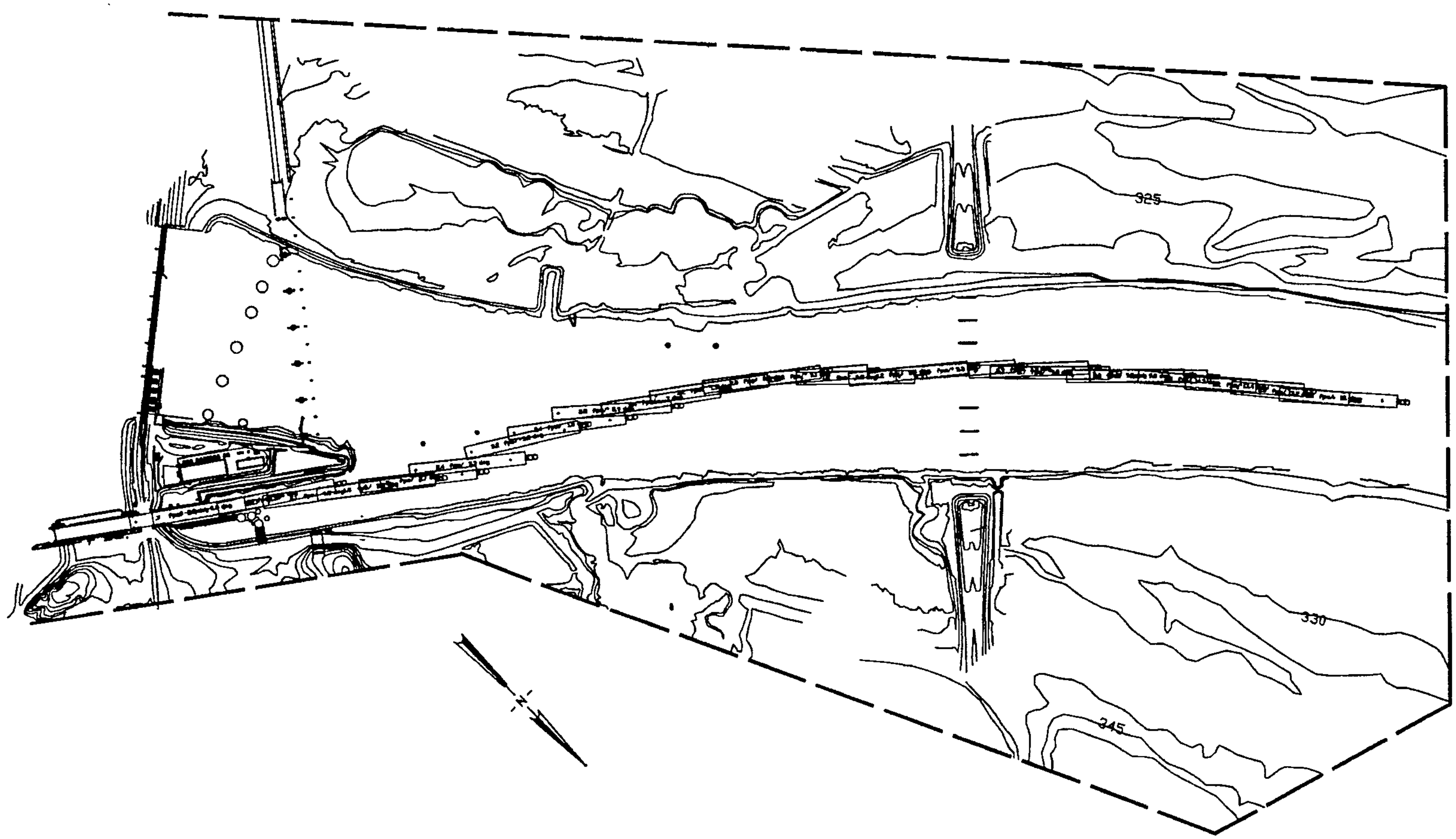
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
COMPLETE COFFERDAM, UPBOUND
DISCHARGE: 155,000 CFS
UPPER POOL EL: 359.0 FT
LOWER POOL EL: 316.0 FT



TOW TRACKS
COMPLETE COFFERDAM, UPBOUND
DISCHARGE: 300,000 CFS
UPPER POOL EL: 362.5 FT
LOWER POOL EL: 328.0 FT
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
LEGEND
NOTE: 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
325
338
345
N



TOW TRACKS

COMPLETE COFFERDAM, UPBOUND

DISCHARGE:	370,000	CFS
UPPER POOL EL:	368.3	FT
LOWER POOL EL:	344.0	FT

LEGEND

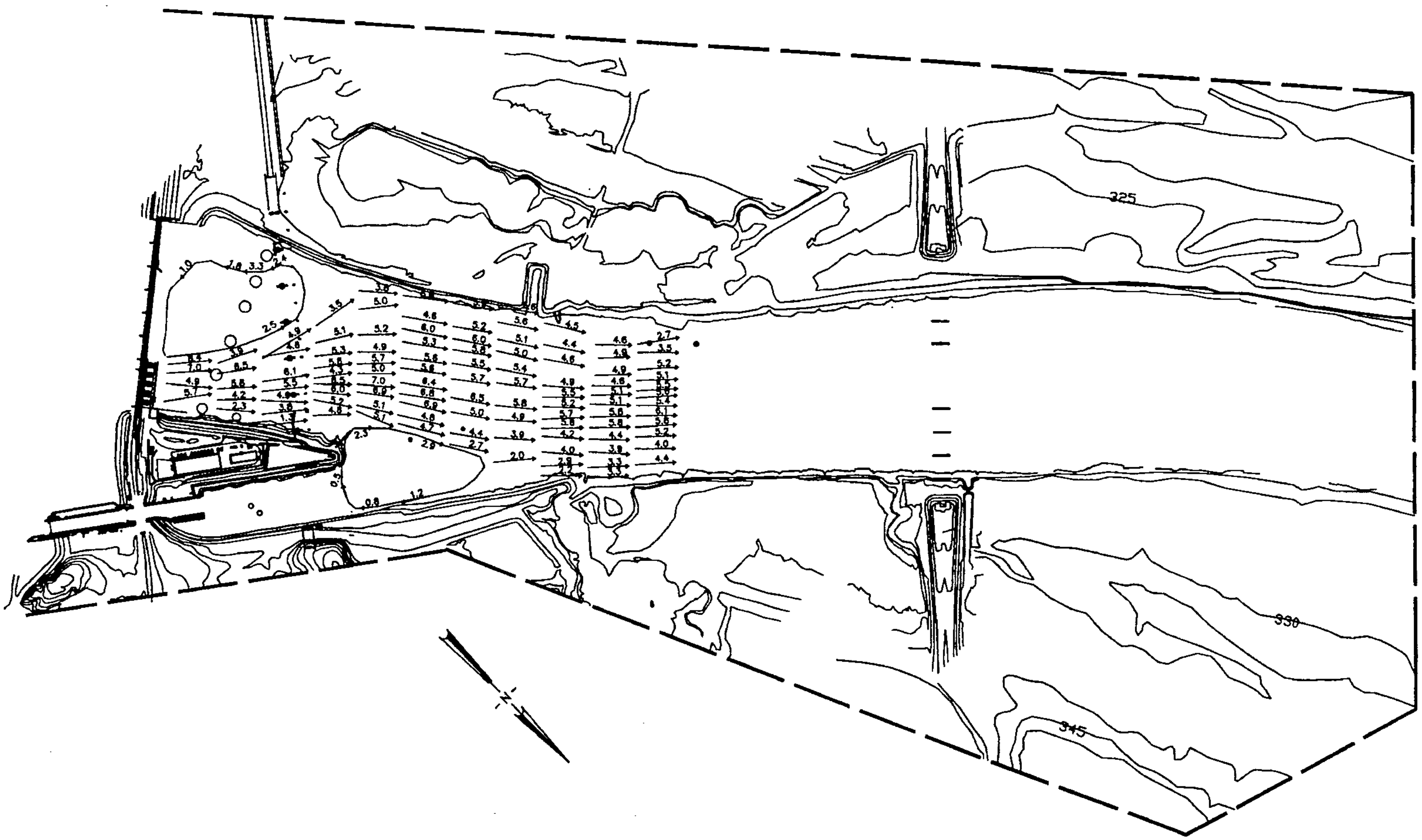
NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20



LEGEND

2.6 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

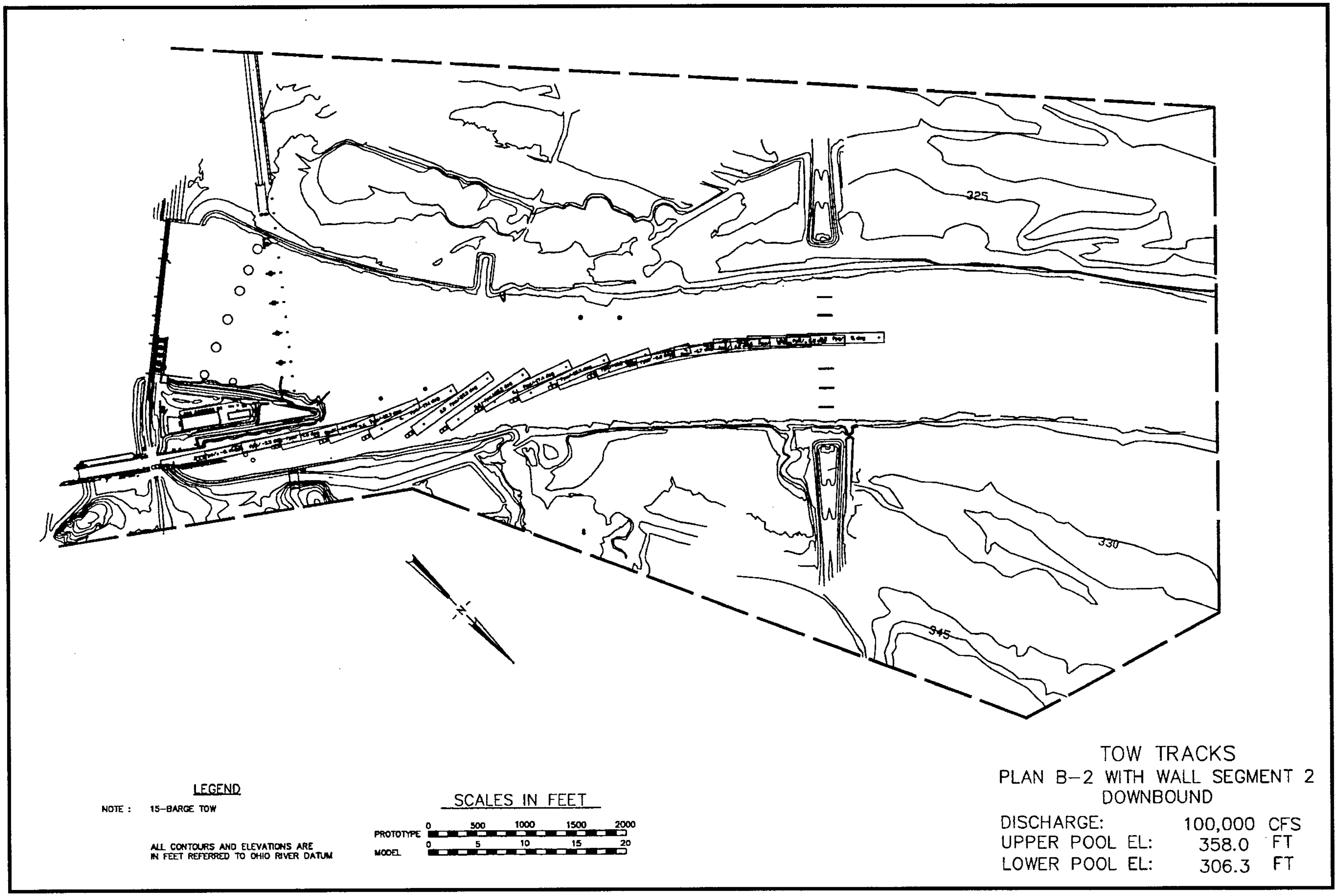
PROTOTYPE 0 500 1000 1500 2000

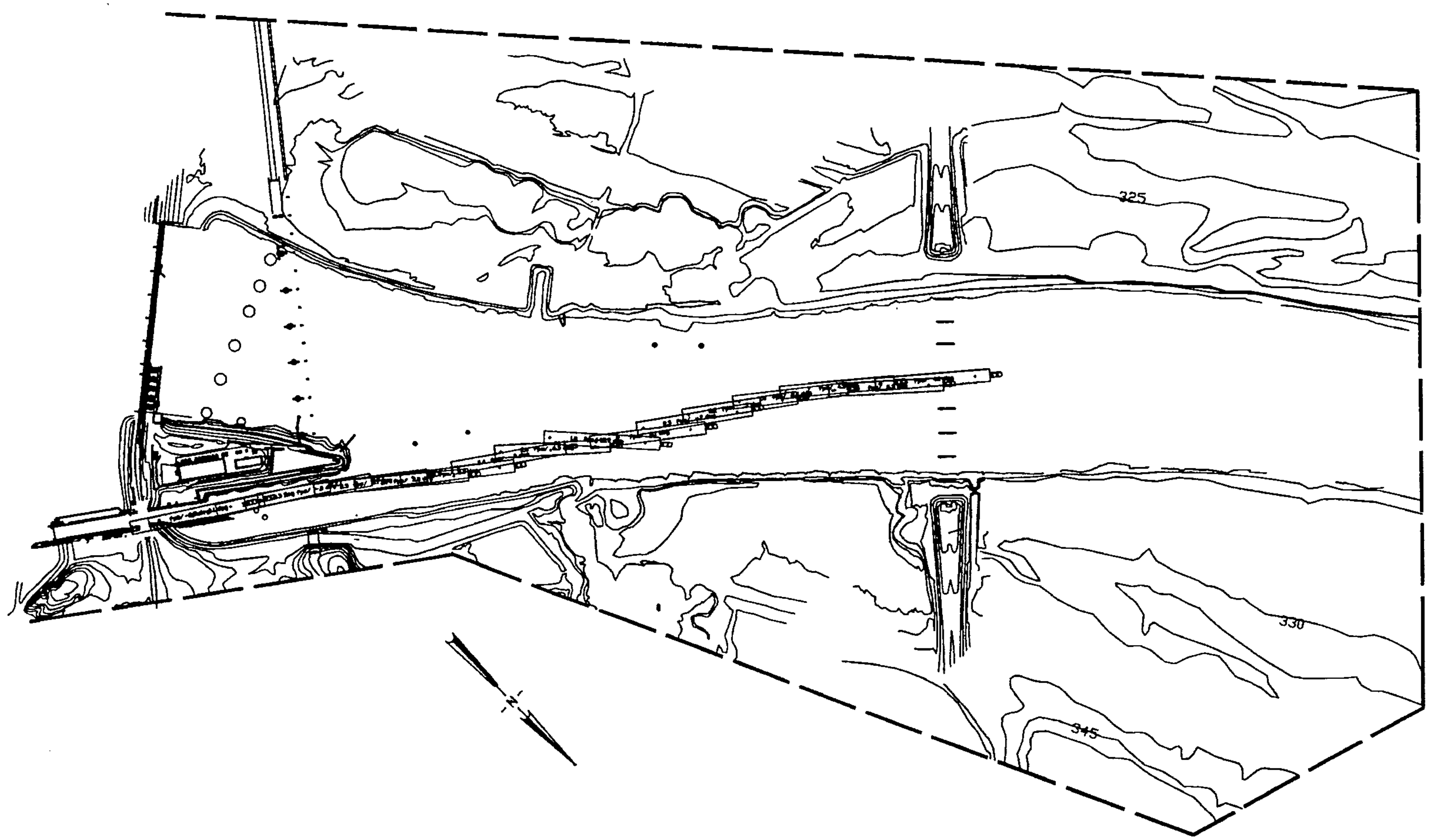
MODEL 0 5 10 15 20

VELOCITIES AND CURRENT DIRECTIONS

PLAN B-2 WITH WALL SEGMENT 2

DISCHARGE:	100,000 CFS
UPPER POOL EL:	358.0 FT
LOWER POOL EL:	306.3 FT


325
330
345
N
LEGEND
NOTE : 15-BARGE TOW
ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM
SCALES IN FEET
PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20
TOW TRACKS
PLAN B-2 WITH WALL SEGMENT 2
DOWNBOUND
DISCHARGE: 100,000 CFS
UPPER POOL EL: 358.0 FT
LOWER POOL EL: 306.3 FT



LEGEND

NOTE : 15-BARGE TOW

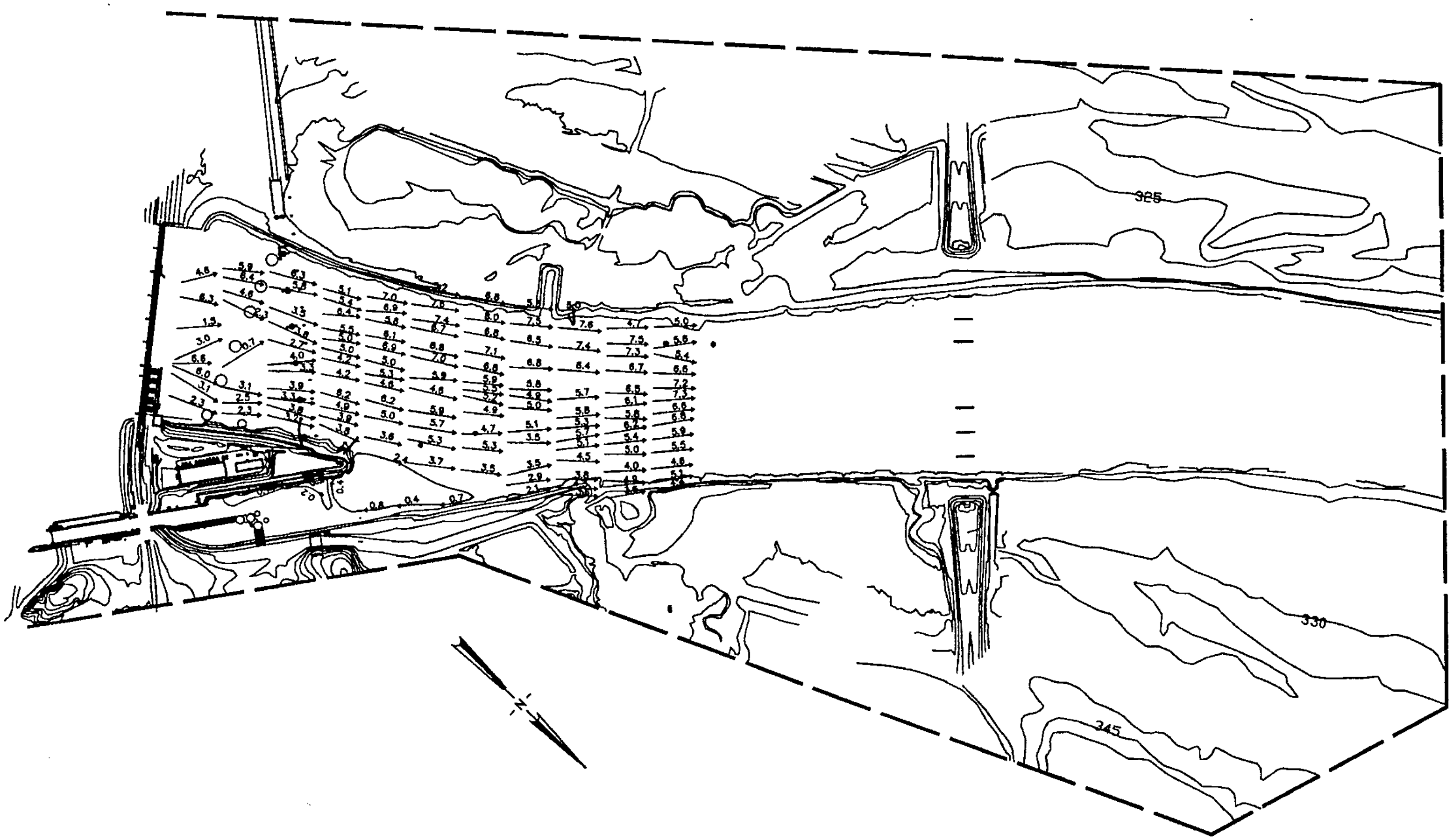
ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20

TOW TRACKS
PLAN B–2 WITH WALL SEGMENT 2
UPBOUND

DISCHARGE:	100,000	CFS
UPPER POOL EL:	358.0	FT
LOWER POOL EL:	306.3	FT



LEGEND

2.8 VELOCITIES IN FEET PER SECOND (FPS)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

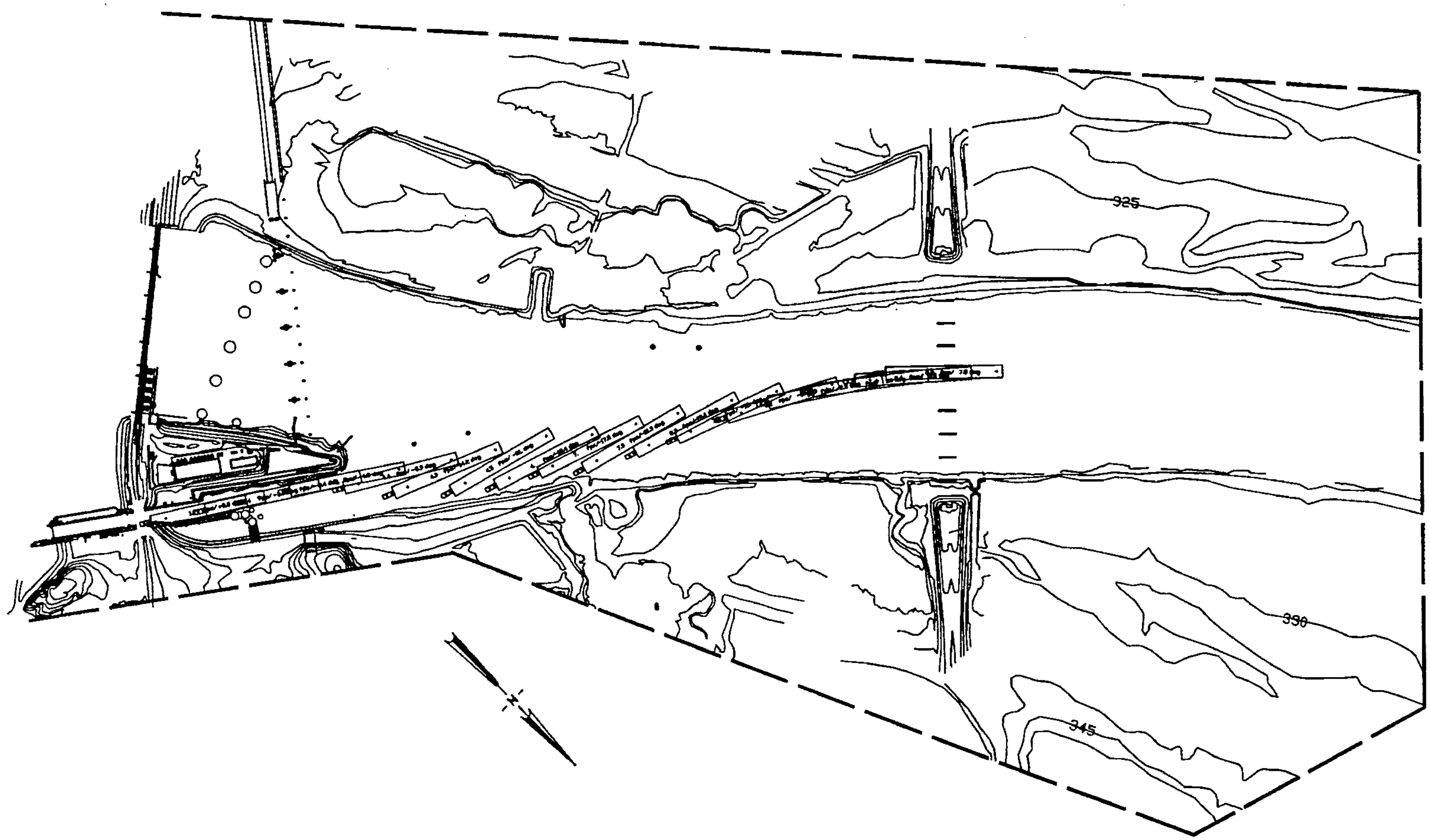
PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

VELOCITIES AND
CURRENT DIRECTIONS

PLAN B-2 WITH COMPLETE COFFERDAM

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



LEGEND

NOTE : 15-BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE
IN FEET REFERRED TO OHIO RIVER DATUM

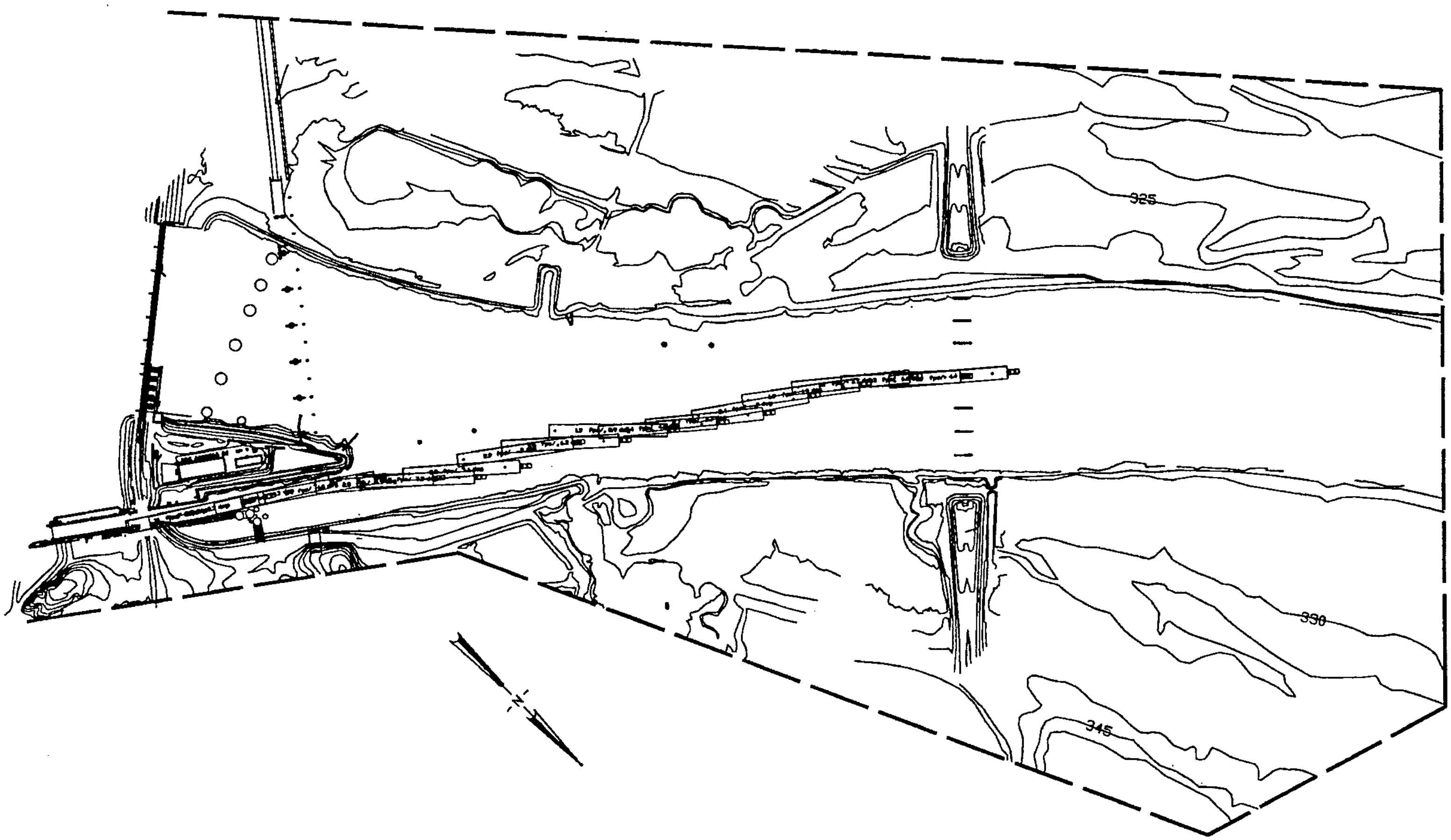
SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000

MODEL 0 5 10 15 20

TOW TRACKS
PLAN B-2 WITH COMPLETE COFFERDAM
DOWNBOUND

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT



TOW TRACKS
PLAN B–2 WITH COMPLETE COFFERDAM
UPBOUND

DISCHARGE:	300,000	CFS
UPPER POOL EL:	362.5	FT
LOWER POOL EL:	328.0	FT

LEGEND

NOTE : 15–BARGE TOW

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO OHIO RIVER DATUM

SCALES IN FEET

PROTOTYPE 0 500 1000 1500 2000
MODEL 0 5 10 15 20